The Dock and Harbour Authority

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Editorial Comments

Malmö.

The subject of our leading article and illustrated Supplement this month is the third of the three leading seaport towns in Sweden. Malmö ranks next in importance to Gothenburg (which has been described in our issue of February last), and stands on the eastern shore of the Sound opposite Copenhagen, from which it is distant not more than 16 miles. This proximity to the Danish peninsula and archipelago, and in a lesser degree to Germany, to which there is a train ferry, influences the trend of the trade of Malmö, though a large and important share of it falls to Great Britain.

Historical records of the place date back to the middle of the 13th century, and during the palmy days of the Hanseatic League, it enjoyed considerable prosperity, being the most important commercial town on the Sound. Then in the 16th and 17th centuries it ceased to flourish, and a large part of its trade was lost owing to the decay of the herring fisheries and the competition of its Danish neighbour, Copenhagen. The enterprise of Frans Suell, a local merchant, did much to resuscitate the fortunes of the place, and he was the initiator of its harbour accommodation, which at the present day has attained important dimensions.

It is interesting to note as a link with English—or perhaps, more strictly, Scottish—history, that the town was the place of imprisonment of the Earl of Bothwell for some time after 1573. It will be recalled that Bothwell was the reckless and determined suitor of the unhappy Mary, Queen of Scots, as she is familiarly known, and the probable murderer of her first husband, the Earl of Darnley. After the episode of the crime in question and his marriage to Mary, he was defeated at Carberry Hill by the Scottish Lords, compelled to flee, captured by a Danish warship and taken to Copenhagen, whence he was removed to Malmö. His prison was the citadel, which still exists, though its use has degenerated to less warlike purposes.

As an important manufacturing and industrial centre, with a wide range of transport to the neighbouring countries, Malmö is in a fortunate position to develop its trade, and our readers will be interested to read the account of the port and its activities, which will be found elsewhere in this issue.

Petroleum Depôts in the Thames.

The location of oil storage sites and the accommodation to be assigned for oil tankers in ports are always matters for serious consideration by the authorities concerned, and the obvious responsibility of the latter is to provide such segregation as will avoid the possibility of a serious conflagration. At the present time, the Port of London Authority announce their intention of applying to the Minister of Transport for confirmation of amended bye-laws, the effect of which will be to permit the loading and discharging of petroleum spirit as far up the river as Purfleet, which is some fifteen miles higher than the present limiting point at Mucking, heavy-oil tankers being already allowed to proceed to the upper boundary. The step is believed to be linked up with a proposal of the Anglo-American Oil Company to provide riverside facilities for handling petroleum spirit at Purfleet, where there is an important storage depôt, but it emanates essentially from the British Government who are desirous of bringing supplies nearer the city in connection with measures of national defence. The alteration has been mooted before and has been rejected in view, *inter alia*, of the risk of collision in a narrow waterway with the danger of a major disaster in the event of a tanker catching fire and dispersing a film of burning oil to be carried upstream by the tide. The present proposal is encountering renewed opposition and, indeed, this is scarcely to be wondered at, notwithstanding the national defence interests involved. The security of frontagers and shipowners would be materially affected by the change and the experience of March 16th last, when the storage tanks of the Anglo-American Oil and Shell-Mex Companies were endangered by a fire which broke out in a waste-paper dump at Purfleet, is not likely to allay fears as to what might happen if the amended bye-laws are sanctioned.

The Belfast Airport.

The opening of the new airport at Sydenham near Belfast, which is within the jurisdiction of the Belfast Harbour Commissioners, is a significant incident illustrating the widening scope of the powers and duties of port authorities. Two years ago the Belfast Harbour Commissioners were given authority to build and operate an aerodrome, and with commendable enterprise they have expended a sum of nearly £60,000 on the reclamation, draining and preparation of a site on the County Down side of the River Lagan, together with the erection of a fine hangar and appurtenant buildings. Having had a recent opportunity of inspecting the structure, we can compliment the Commissioners and their officers on the achievement of an undertaking which redounds greatly to the credit of the port. The airport is available both for seaplanes and for aeroplanes. The development of sites for the use of aircraft within harbour areas is becoming a feature of modern port administration, and port authorities will obviously have to concern themselves in an increasing degree with the provision of suitable accommodation.

German Inland Waterway Traffic.

From the report on the developments of German inland waterways in 1937, which we are able to publish this month through the courtesy of Ministerialrat Herr E. Leopold of the Reichsverkehrministerium, Berlin, it will be seen that the German authorities are continuing to pursue actively a comprehensive programme in the extension and development of inland water routes. This policy is eminently justified by its results, for simultaneously with the constructional measures in hand, there has been a pronounced augmentation in the volume of traffic. The year 1937 was, in fact, quite a prosperous year in this respect, the former peak figures of 1929 having been exceeded, and an increase of something like 10 per cent. realised over last year's returns.

In regard to the operation of these inland waterways, it is stated that there is a tendency towards the increased use of mechanical power and, in particular, of power-driven barges. In this respect, British canal traffic is at a disadvantage, and too much reliance is still placed in old-fashioned and obsolete methods of traction. The main difficulty, of course, is that the banks of many waterways in this country are not conveniently adapted for the introduction of mechanical tractors, nor are they suitably protected to withstand the wash induced by high speed propulsion. It is regrettable, however, that these drawbacks should be allowed to exercise a detrimental effect on the development of British inland water-borne traffic, which still languishes despite the attention which has been given to the matter during past decades by Royal Commissions and Departmental Committees. The slow and tardy efforts of the authorities to deal with the cumbrous and involved problem of the British Canal system, while understandable enough in view of the difficulties which have to be surmounted, does not redound greatly to the credit of British enterprise and initiative. It is

Editorial Comments—continued

a matter of growing and serious concern that things are still allowed to drift without any attempt at putting into execution plans which have been formulated in competent quarters and have been put forward with the endorsement of official approval.

Port Emergency Committees.

In the early part of last month, during the course of the debate in the House of Commons on the Government's Defence programme, Sir Thomas Inskip, the Minister for the Co-ordination of Defence, made a welcome and reassuring statement in reference to the arrangements for dealing with port traffic in time of war. Attention has previously been drawn in this Journal to the chaos which prevailed during the Great War, and it has been pointed out how essential it is that due regard should be paid to the economic and trading requirements of the country no less than to the military needs of a campaign. It will be learned with relief that competent Port Emergency Committees have been set up at 45 of the principal British commercial ports, consisting of representatives of the respective port authorities, coastwise shipping, home trade and overseas shipping interests, together with representatives of the railways, road users, general trades and canals. The comprehensive character of these committees is all that can be desired, and it is only necessary that proper consideration should be given to their advice by the military authorities (who, presumably, will be in supreme command in the event of hostilities) to ensure a sufficient flow of commodities through the ports without detriment to the movement of troops and armaments. Indeed, Sir Thomas went so far as to express himself in unmistakable terms.

He said that the Government had determined on one principle which he commended to the House, viz., that even in war time, the port authorities must continue to exercise their normal control. When he spoke of normal control, he meant that it would be impracticable to substitute a new authority for those familiar with the local conditions, and what was needed, of course, was a proper consideration of the increased demands that might be made upon the ports in question. "Was there enough quay space? Was the rolling stock likely to be adequate? Were the railway sidings laid out in a proper way? Was labour likely to be forthcoming? The whole of these necessities had been borne in mind, and calculations had been made which enabled him to say that when the arrangements as a whole had been made in the ports there was capacity there to handle any traffic that might be diverted." He added that no doubt a good deal of traffic would have to be diverted from the East Coast to West Coast ports.

From this, Sir Thomas went on to speak about the efficiency of the merchant service and its capacity to deal with the national trade and, in particular, the food-carrying services during the prevalence of war-time conditions, and he quoted from a report of the Liverpool Steamship Owners' Association a statement to the effect that "having regard to the increase in carrying power resulting from improved methods of construction, there is no reason to think that the present-day British Mercantile Marine is any less an efficient cargo-carrying instrument than it was in 1914." Coming from an authoritative source, this assurance would carry complete conviction were it not that a shipping Journal has recently published figures to show that the present gross tonnage of the British cargo and passenger fleet is nearly four millions less than it was in 1914, while the corresponding tonnage of vessels owned by other countries has risen by thirteen million tons. Ignoring this discrepancy, the contention may be urged, of course, that in view of the pronounced increase in foreign tonnage, there would be less likelihood of a heavy demand on this country to supply the deficiencies of its allies, which were only too obvious in the last war and threw a great strain on the shipping resources of Great Britain. Yet there is still a counter argument. During the war the shipping tonnage of certain neutral countries was requisitioned by Great Britain and paid for by supplies of bunker coal. The immense development of Diesel oil propulsion in Scandinavia and Holland, from which these shipping auxiliaries were chiefly drawn, makes bunker coal relatively of little value now for bargaining purposes.

While the situation as explained by Sir Thomas Inskip is satisfactory at the present time, the nation must not be allowed to lull itself into complacency and a false sense of security. The arrangements, enterprisingly undertaken and efficiently begun, must be perfected and extended, for there is still abundant scope for a continuance of effort in the safeguarding of trade and food supplies in time of war. The questions of storage and of inland transport are no less important than the efficient operation of ports. And here again we may be permitted to remind our readers of the plea which has been urged for action on the part of the Government in reviving and extending the use of British canals and inland waterways. We would direct their attention to the preceding comment on the progress made in the development of German waterways.

Estuarial Obstructions.

In a remarkable Paper contributed to the Institution of Civil Engineers on February 8th, Professor A. H. Gibson set out the results of his investigations by means of models into the effect of bridge piers and other obstructions on the tidal levels in an estuary. The Paper is being reproduced elsewhere in this issue, and we commend it to the attention of our readers, for it calls for the careful consideration of all who have to deal with the problem of interference with tidal and river flow constructional works. The startling conclusion arrived at by Professor Gibson is that, in spite of all preconceived ideas on the subject, "the experimental results indicate that an increased construction of the waterway in a tidal estuary does not necessarily involve a diminution in the volume entering and leaving the upper estuary tide. On the contrary, in estuaries of the type and proportions examined, a constriction of section up to a certain point increases the level of high water at all points above the constriction and increases the volume entering and leaving." This is a hard saying, and it has been received, not unnaturally, with a good deal of scepticism. It seems a direct contradiction of what common sense and experience would appear to indicate and, indeed, the matter can hardly be left without further confirmation and an explanation of the apparent anomaly. Professor Gibson's experiments were, of course, limited in scope, and were confined to cases of rivers, such as the Severn (with which nobody is more familiar than Professor Gibson himself) and the Dee, where the proposed obstructions were of considerable extent, i.e., of the order of upwards of 50 or 60 per cent. That such important constrictions of the waterway should lead to the results stated would appear to involve a surprising increase in current velocity, which in the absence of a reasonable explanation can only be accepted with reserve. Our readers will welcome some further enlightenment on the subject.

The St. Lawrence Ship Channel.

The decision of the Canadian Government to continue the work of deepening the bed of the St. Lawrence River so as to afford a navigable channel for shipping, 35-ft. deep, from Montreal to the sea, has been welcomed in Canadian shipping circles. The original dredging programme was based on the low-water datum of 1897, but the fall in level by 2-ft. in 1934 had materially altered its value, and the intention of the Government now is to follow the majority recommendation of the Water Levels Board and provide a 35-ft. channel based on extreme low-water level.

The improvement of this great shipping route penetrating right into the heart of the Dominion is a matter of interest to all engaged in promoting the development of navigation, and particularly to the ports of Montreal and Quebec, the important commercial centres on the banks of the waterway in question.

Hull Port Administration.

The movement expressive of dissatisfaction with the alleged present lack of policy in port development by the London and North Eastern Railway Company, commented upon in our preceding issue, was the subject of further discussion by the Council of the Hull Chamber of Commerce and Shipping at their meeting in March. Strong dissent was expressed on behalf of the timber trade to the proposal to promote the creation of an independent port authority, and this view was also supported by representatives of the grain trade and the fruit trade. In the end it was decided to set up a sub-committee of the Council, consisting of two representatives from each section of the Chamber "to consider the existing facilities and accommodation of the port, with a view to improvement."

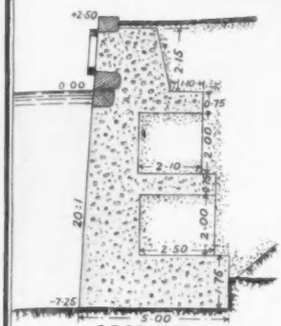
It is clear that the proposal to disturb the existing administrative authority of the port does not command the substantial support of the Chamber and, indeed, some will feel that the strictures passed by individuals on the Railway Company were hardly justified in view of the activity the latter have displayed in recent years in a number of directions. As we pointed out in our previous comment, the Railway Company have effected a number of notable improvements and extensions of accommodation at the port, and though perhaps the desires and expectations of all the various trades have not been fully met, yet there is sufficient evidence to show that the Company are alive to the needs of the port and their own responsibilities in the matter.

Port of Barranquilla.

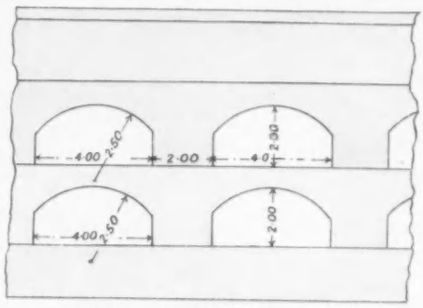
In the leading article last month it was stated that the firm of Sir Alexander Gibb and Partners was represented on the site by Mr. Hugh Beaver, one of the partners. We have since been informed that the firm's representative in Colombia responsible for various stages of the works on the Magdalena River and Port of Barranquilla have been the late Col. P. R. Warren, M.Inst.C.E., the late Mr. F. W. H. Stileman, M.Inst.C.E., and over the last three and a half years during which the bulk of the work has been done, Major P. H. Thorne, M.C., M.Inst.C.E.

PORT OF MALMÖ.

CHIEF ENGINEER TO THE MALMÖ HARBOUR BOARD:— Mr H. G. WACHTMEISTER.

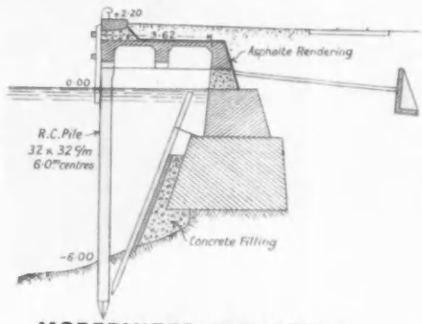


SECTION.

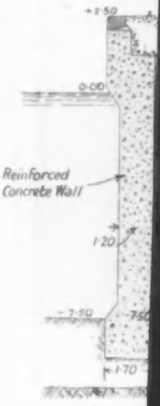


BACK ELEVATION.

QUAY WALL — OUTER HARBOUR.



MODERNIZED QUAY WALL. INNER HARBOUR.



QUAY WAL

Scale for Quay Walls & Dolphin

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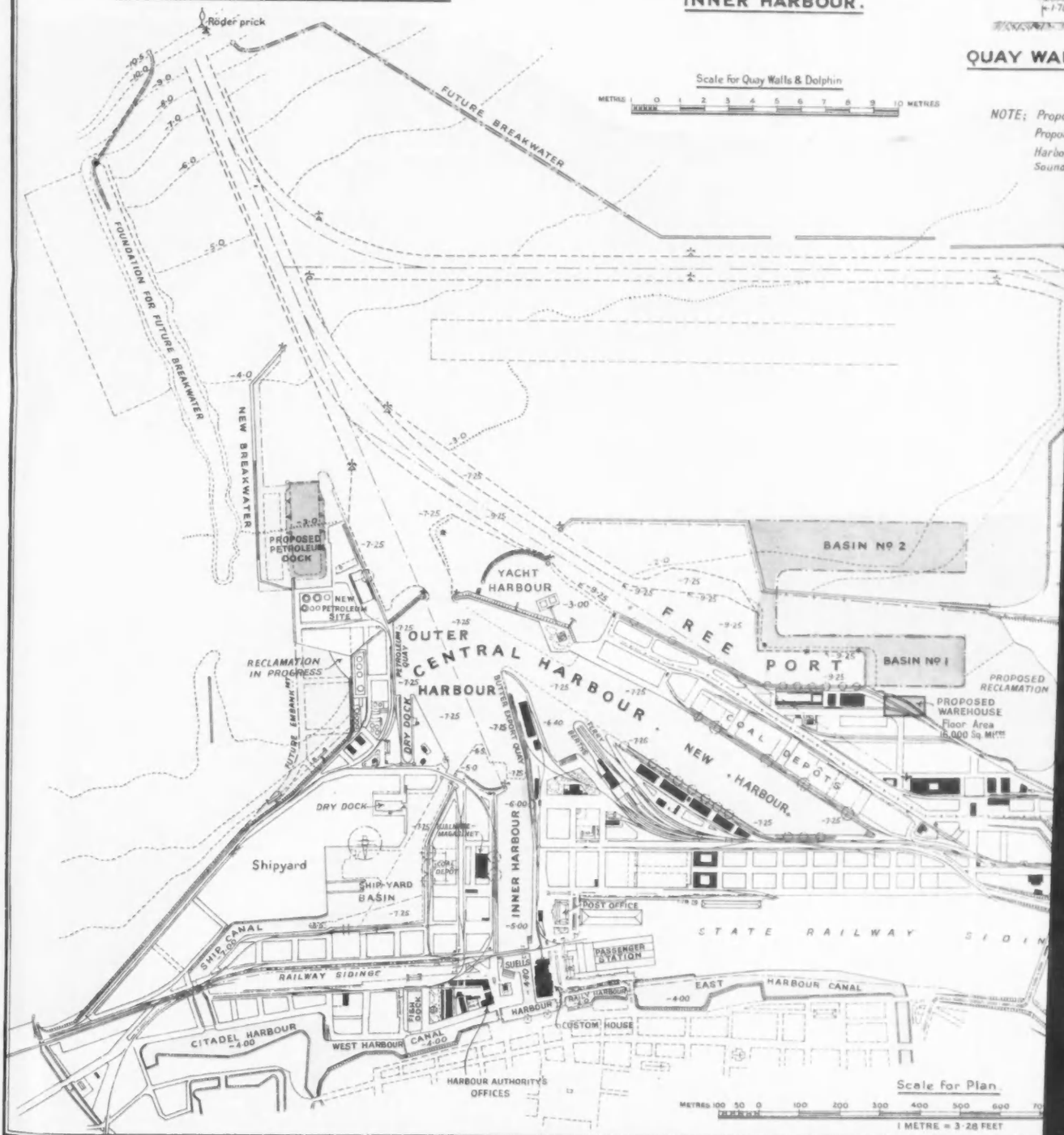

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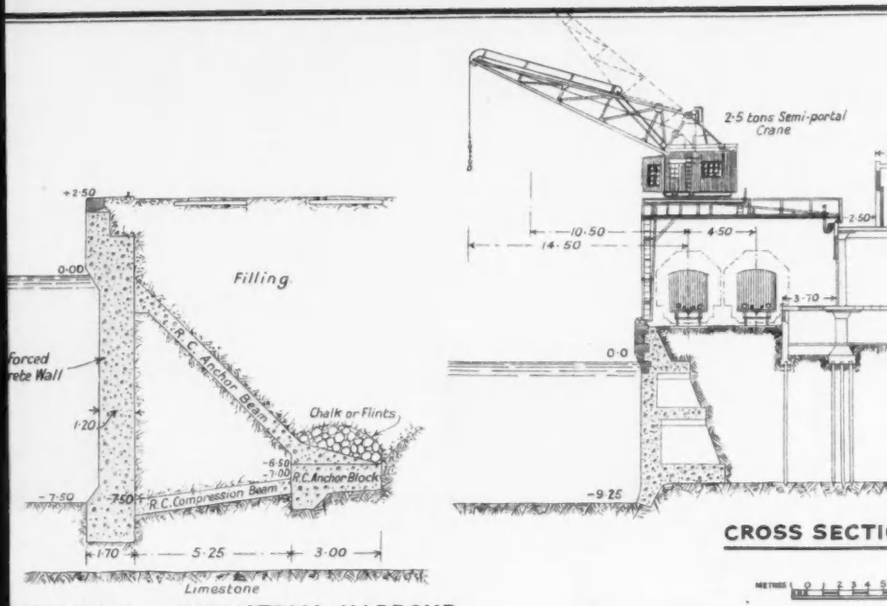
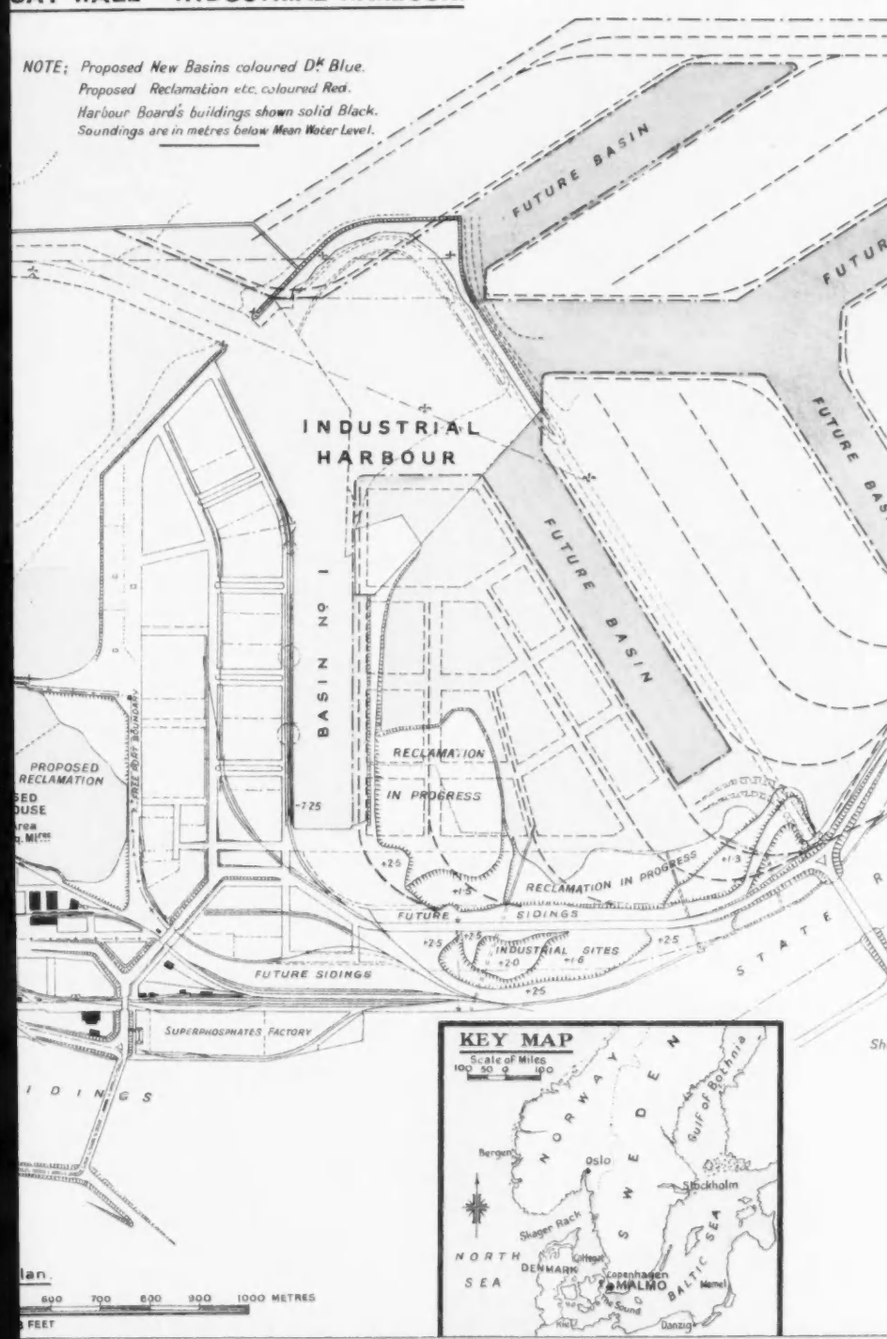
K AND HARBOUR AUTHORITY, APRIL, 1938.



CROSS SECTI

UAY WALL — INDUSTRIAL HARBOUR.

NOTE; Proposed New Basins coloured Dk Blue.
Proposed Reclamation etc. coloured Red.
Harbour Board's buildings shown solid Black.
Soundings are in metres below Mean Water Level.



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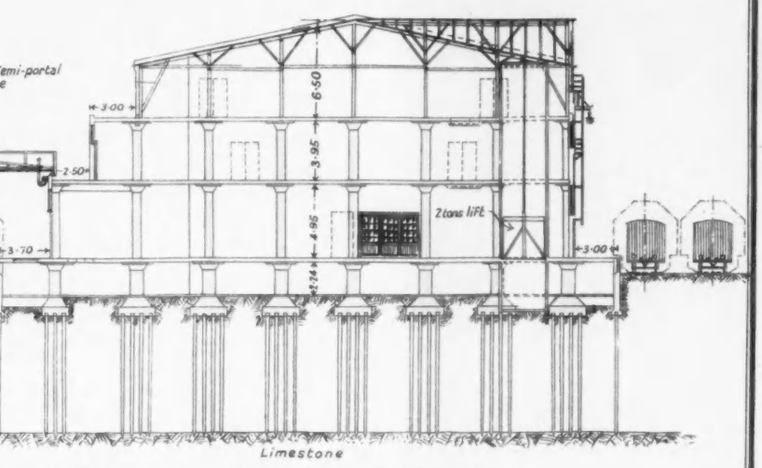
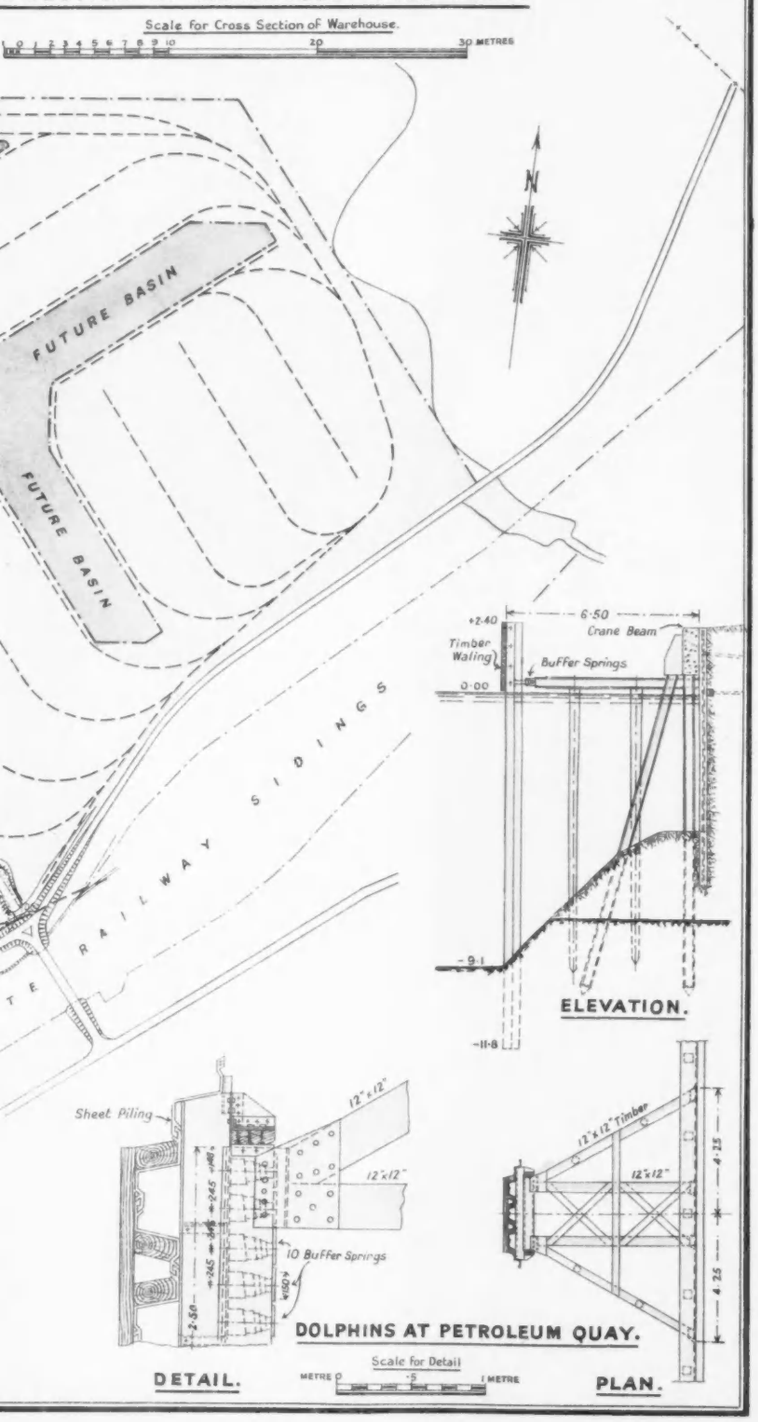


S SECTION OF WAREHOUSE — FREE PORT.

Scale for Cross Section of Warehouse.



DOLPHINS AT PETROLEUM QUAY.

DETAIL.

Scale for Detail

PLAN.

The Port of Malmö

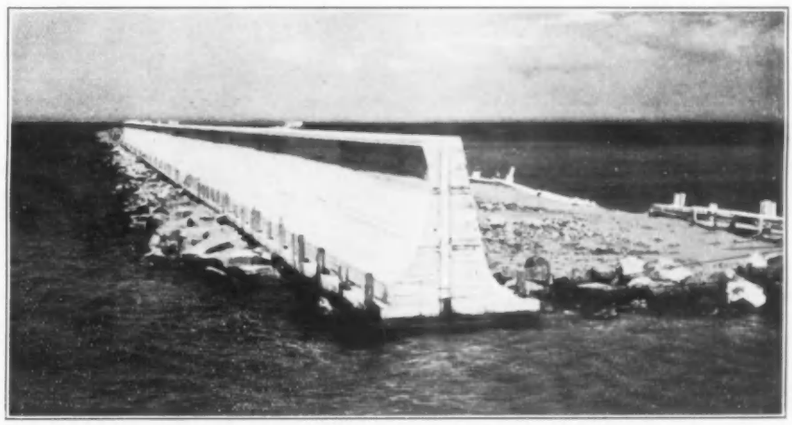
A Thriving Swedish Seaport

By G. EDLUND, General Manager of the Port

General

THE City of Malmö is situated on the Sound, well known to all seafaring people as the natural gateway between the North Sea and the Baltic. On account of this strategic position, Malmö has risen to become one of the most prominent ports of the North.

At present the population of Malmö numbers about 145,000—the city being the thriving centre of a hinterland of high agricultural and industrial development, with a close network of railroads and splendid highways.



Parapet West of Main Entrance Channel.

Historical

Although the city celebrated her six hundredth anniversary in 1919, she has not been in possession of a harbour for more than a quarter of her lifetime.

Not until 1775 was the first "Harbour Construction Authority" established by the "Society of Merchants." This Society was presided over by Frans Suell, now honoured with a statute at the oldest harbour basin, known as the Suells Harbour.

Up to 1775 the only means of communication with sea-going vessels were high-wheeled carts, upon which the goods were carried ashore, a method which obviously involved great risks.

As the natural coast conformation was unsuitable, the harbour had to be developed on wholly artificial lines. The shallow water outside the mediæval fortified shore-line covered a layer of glacial clay with a thickness of 20 to 30 feet, resting on a limestone bed. The formation of the harbour therefore has consisted in dredging and reclamation work and in the construction of quays and other facilities for handling cargo.

The work commenced by the first Harbour Authority has been carried on incessantly, and has up to present time resulted in the creation of a large number of basins and channels with a total length of quays of over 5 miles and a land area of more than 400 acres.

Administration

Like the majority of Swedish ports, Malmö is municipally owned and operated under the jurisdiction of a Harbour Board comprising 10 members, one of them being Chairman. The members are appointed by the City Council and hold office for a period of four years.

The management of the Customs Port is in the hands of a General Manager, appointed by and under the direction of the Harbour Board. There are three administrative departments: the Technical Department under the Chief Engineer, the Post Office under the Captain of the Port, who regulates the traffic, and the Finance Department under the Chief Accountant.

The control of the Free Port and the handling of goods therein are in the hands of Malmö Free Port Company, under the same management as the Customs Port. The company devotes itself exclusively to the management of the Free Port and has charge of warehouses, cranes and other facilities, together with all the handling of cargo within the Free Port area.

Harbour Entrance

Access to the harbour of Malmö is conveniently gained through one main entrance channel, dividing into three branches, each leading to one main section of the harbour.

Thus the channel leading to the Central Harbour has a length of 5,000-ft., a width at the bottom of 262-ft., and a depth of 23-ft.; the channel to the Free Port is 5,300-ft. long, 197-ft. wide and 30-ft. deep, and finally the channel to the Industrial Harbour has a length of 9,000-ft., a width of 197-ft. and a depth of 23-ft. All lengths given are measured from "Röder Prick," the automatic light and sound buoy at the outer end of the main entrance channel to pier heads—the depth is measured from mean water level.

As a protection against storm and waves, a breakwater (see Supplement) has recently been constructed west of the main entrance channel. Its parapet has a length of 1,800-ft. and a height of 15-ft.

Tides and Ice

Along the coast of Sweden the water level is practically unaffected by tidal influences. Variations of about 3-ft. above or below mean level, exceptionally occur at Malmö, and are caused by high winds.

The Port of Malmö has very seldom experienced winters cold enough to create any obstruction for traffic through ice. In case of emergency the harbour authority keeps an efficient ice breaker for service in and about the vicinity of the harbour.

Interior View of Quay Shed.

Railways

The railway service sidings of the harbour have a total length of over 50 kilometres, and have direct connection with the State Railways, with which the system is operated.

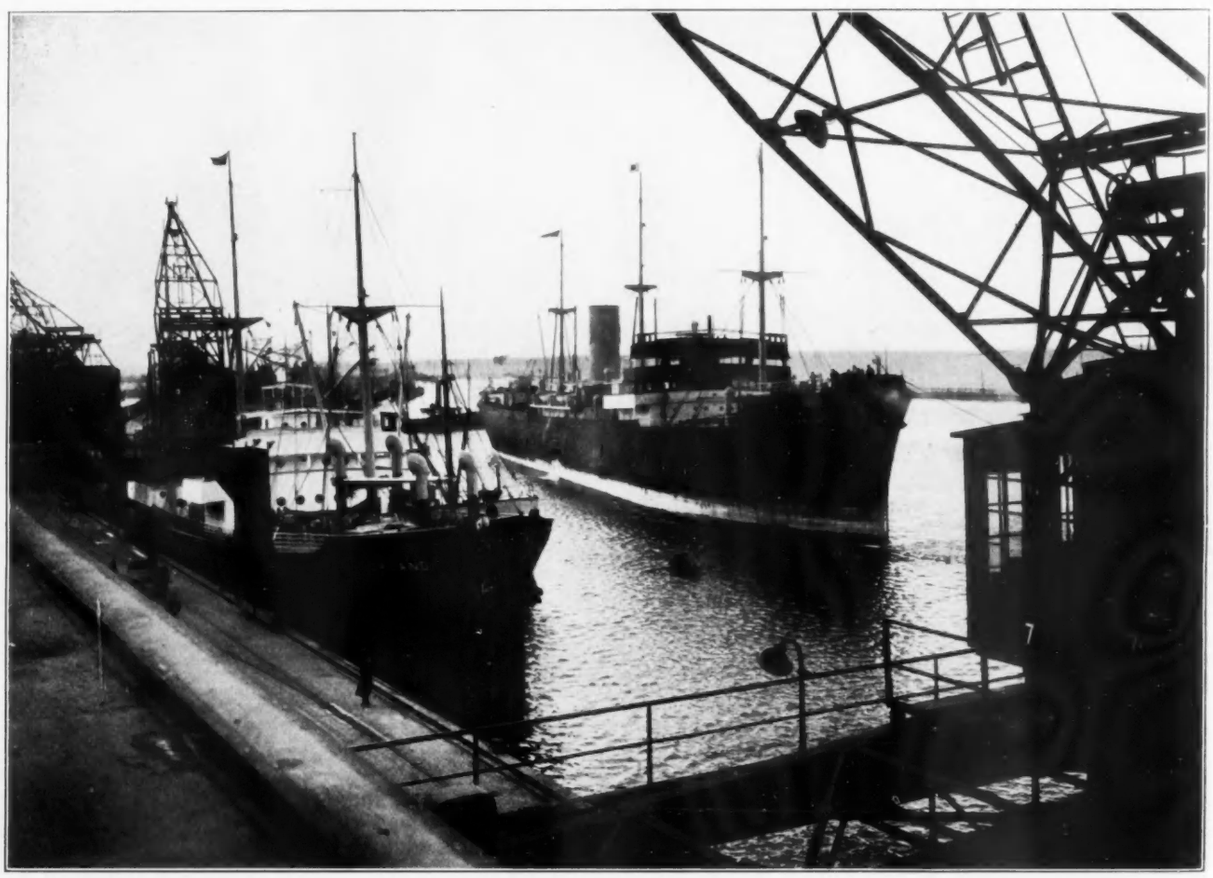
The Central Harbour

The Central Harbour is formed by a large swinging basin, the so-called Outer Harbour, leading towards the south-east to the New Harbour, and towards the south to the Inner Harbour. In a south-easterly direction, a short channel, spanned by a lift-bridge, leads to a large almost square basin, the so-called Shipyard Basin.

The New Harbour was completed in 1903, and has a depth of 23-ft. and a breadth of 500-ft. It is built with quay

Port of Malmö

Shipping in the Free Port.



Quayside of Free Port.

Port of Malmö—continued

walls of mass concrete, excepting the south-westerly quay, which consists of a wooden bulwark supporting a concrete wall.

In the middle of the basin are located three moorings.

On the south-westerly quay of the New Harbour are situated a number of warehouses served by four electric cranes of 2 tons and three cranes of 3 tons lifting capacity, all movable. There is also erected one fixed electric crane of 15 tons lifting capacity.

On the south quay of the New Harbour basin goods generally are conveyed from ships directly to railroad cars or lorries. For this purpose, there are available two electric cranes of 3 tons lifting capacity and one crane to lift 5 tons.

On the north-easterly quay of this basin are located the coal depots of the Sydkraft power company, of the city gas works and of four private firms: A/B Skaneimporten Kolkoks, A. Johnson & Co., Ernst Thestrup and A/B A. Scholander & Co. The coal and coke imported by these firms are unloaded by means of five bridge cranes with lifting capacities varying from 4 to 6 tons. These firms are also engaged in the business of coal bunkering.

In direct communication with the Outer Harbour lies towards south the older Inner Harbour with a depth of 17-ft., connected with a system of basins and canals for smaller craft.

The regular traffic to and from Denmark is wholly dealt with in the Central Harbour. The passenger vessels of the Öresund Steamship Co. have their berthing places on the east quay of the Inner Harbour and the steam-ferries of the Swedish and Danish State Railways berth in the New Harbour, just east of the pier separating these two basins.

This pier has been allocated to the new three-storey building for cold storage and testing of export butter, recently erected on the pier. The bottom floor of the building is used as a warehouse. The maximum output from the butter cold storage amounts to 600 tons, equalling 12,000 kegs of butter a week.

The west quay of the Butter Export Pier is constructed with steel sheet piling. The quay has a length of 670-ft. and a depth of water of 23-ft. On this quay there is placed one electric crane of 1½ tons lifting capacity, and there will shortly be erected a new 6-ton crane, built on the level-luffing system.

At the southern end of the Inner Harbour is situated on the east side the Custom House, and on the west side the building of the Harbour Authority.

Further to the north, on the west side of this basin, there is located a one-storey warehouse, Hjälmaremagasinet, with two level-luffing cranes of 3 to 5 tons lifting capacity.

The system of quay construction in the Inner Harbour is shown in the Supplement.

The above-mentioned Shipyard Basin has a depth of 23-ft. As its name indicates, the shipyard and mechanical works of Kockums Mekaniska Verkstads A/B are situated on this basin. At the Kockums Shipyard there is a steel sheet piling quay with a length of 600-ft. and a giant hammer crane, capable of dealing with lifts of 80 tons.

Within easy reach from the shipyard there are two dry docks, the smaller of which can take vessels 205-ft. long, and the larger, vessels with lengths up to 523-ft. These dry docks are both municipally owned, the larger one being, however, leased to the shipyard.

On the eastern quay of this basin is situated the coal company, A/B Kolkompaniet, who possess three bridge cranes, two lifting 6 tons and one 4 tons.

Aerial View of the Harbour.

On the southern quay of the Shipyard Basin is located the large grain mill, belonging to the Malmö Stora Valskvarn. This company owns a grain elevator capable of dealing with 640 tons per day.

Petroleum Harbour

The west side of the Outer Harbour is formed by the old Petroleum quay. Here are the oil depots belonging to Texaco and Standard Oil Co.

West of the entrance channel and outside the pier-heads of the Outer Harbour land has been reclaimed for a new petroleum harbour, being a direct extension of the present petroleum grounds. On this new site the oil depot and bunker station of Skanditank and the oil bunker depot of Alfred Olsen & Co. have been erected.

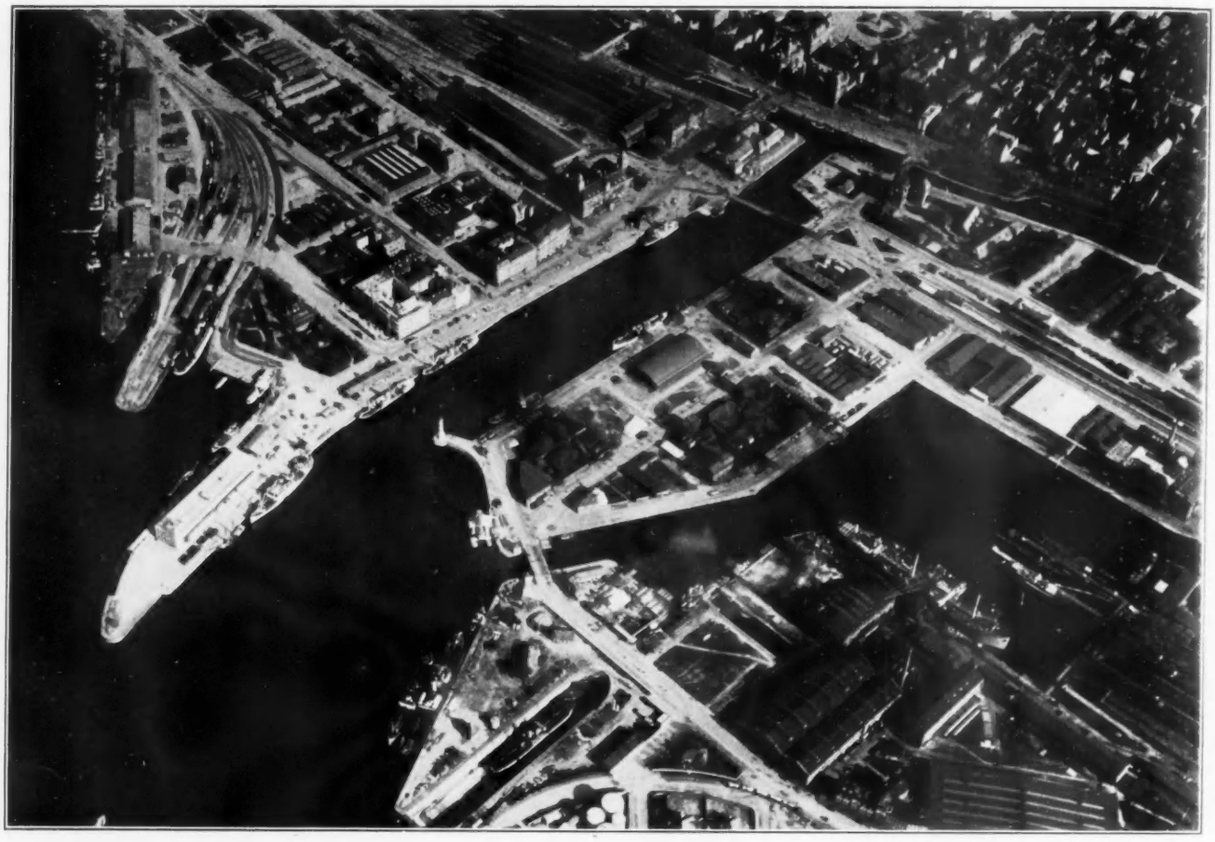
The above-mentioned firm A/B Kolkompaniet also works a coal bunker plant on this site. They own one bridge-crane with travelling grab and a lifting capacity of 4 tons, and one full portal crane with grab and a capacity likewise of 4 tons.

The bunkering of vessels takes place at 11 dolphins, spaced along 700-ft. of the east side of the reclaimed area. Maximum draft for bunkering vessels is at present 24-ft., but plans are proposed for a petroleum dock with accommodation for vessels up to 30-ft. draught.

Industrial Harbour

The Industrial Harbour is the most easterly part of the harbour, and consists of an outer swinging basin leading into another recently constructed Basin number I. The plan of the harbour shows provision for future extensions with four more basins.

Port of Malmö



The South-Westerly Quay of the New Harbour, Part of the Outer Harbour, the Inner Harbour and the Shipyard Basin.

Unloading Motor Cars in the Free Port.

Port of Malmö—continued

At present the Industrial Harbour has a quayage of about 3,600-ft. and a depth of water of 23-ft. In this harbour building lots are available for various industries. On the quay are located three travelling electric cranes and one electric bridge crane, all with grabs. The bridge crane has a lifting capacity of 6.5 tons, and the portal cranes 6 tons. Two of them are owned by the Harbour Authority. There are still two more travelling cranes with a lifting capacity of 6 tons under construction for the Harbour Authority.

In the Industrial Harbour the Malmö Silo Aktiebolag has a silo building with a grain elevator. Further, there are several factories and storehouses, among others the stores and offices of Bröderna Edstrand A/B and Söderberg & Haak A/B, both in the steel line of business.

Free Port

Malmö Free Port was opened in 1922. At present the Free Port has a quayage of 2,250-ft., and a depth of water of 30-ft. Its equipment includes 10 travelling electric cranes of semi- and full portal types, with a lifting capacity ranging from $2\frac{1}{2}$ to 6 tons, four of the cranes are equipped with grabs.

Actually, in 1922 there was warehouse accommodation extending to about 16,000 sq. metres. In this warehouse are installed six elevators, having a lifting capacity of 2 tons each. As early as 1924 it became clear, however, that the warehousing accommodation under cover was insufficient to meet demands, and therefore another warehouse was built along the quayside in that year. Owing to the steadily increasing requirements, new warehouses and storage sheds have been built, so that in 1930 the total warehouse and shed accommodation amounted to about 22,750 sq. metres, and in 1935 to about 27,370 sq. metres. The building of another large warehouse and a number of travelling electric cranes is contemplated.

Malmö Free Port has an independent railway station with a complete goods service, and from a traffic point of view, is on a level with Malmö Central Station. There is also a post office in the Free Port.

The Malmö Free Port Company carry out all work in the Free Port. Owing to the quite modern equipment and excellent facilities of the port, the company are in a position to charge exceedingly low rates for the work effected. Shipping is facilitated because vessels can enter the Free Port, discharge and load their cargoes without any Customs control. Suitable offices and warehouses can be acquired within the area of the Free Port, where goods can be unpacked, sorted, blended and marked without any Customs supervision. The reason for this is that inside the Free Port the goods are outside the territory of the Customs Authorities. Other advantages are that faulty goods can be returned without any Customs formalities, and goods can be cleared through the Customs rapidly owing to the concentration of the business.

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*The Economic Future of Canals**

By GEORGE CADBURY, M.Inst.T.

Discussion on a Paper read before the Institute of Transport on December 13, 1937

The Chairman, **Sir Cyril Hurcomb,** said that Mr. Cadbury, who was a great man of business, a great user of transport, and one who had always taken interest in transport, and particularly in inland water transport, had approached his subject in a practical way. He did not suggest, for example, that the canals should be drained and turned into roads, as certain people had suggested to the Ministry of Transport.

Much that Mr. Cadbury had said about a toll policy was of interest, as was also his suggestion respecting organisation. As an alternative to the previous suggestions of a National Waterways Board or Regional Trusts, Mr. Cadbury had suggested that there should be unified control over a river or a route. That was a suggestion which he had not seen developed in official reports, and Mr. Cadbury had put it forward in a very interesting manner.

When one was considering some change of organisation, it was not the specific economies which could be measured in money to which one had to look. Rather should one look at the advantages resulting from a more centrally focused direction, and from the ability to view problems and policy as a whole, in conditions under which the management would have a free hand, free from the encumbrance of having to negotiate with and agree, or fail to agree, with a number of separate entities making up a route. That seemed to him a cardinal principle when considering what would be a satisfactory type of central authority which should be adopted in the present case, he was very interested to see that Mr. Cadbury endorsed it in relation to the problem of canals.

It had been suggested in the paper that the transport of large pieces of machinery, which the railways could not get through their tunnels and which were sometimes inconvenient on the roads, might well be effected by canal. He had often wondered why some of the heavy loads were not taken by water more frequently than was in fact the case. Mr. Cadbury regarded that as entirely practicable.

Mr. Cadbury also quoted some figures from the report of the Royal Commission of 1905-6. His recollection was that some of the figures of originating tonnage then given were inflated, because the tonnage originating, under their definition, included in some cases the same tons in respect of more than one canal. Attention had been drawn to that point by the Ministry of Transport, and duplicated tonnage had been eliminated from their own statistics. It did not affect the value of the point which Mr. Cadbury made, but it might involve some modification of the actual figures given. He would like to look into that.

(Note by Sir Cyril Hurcomb. Since making the foregoing remarks I have refreshed my memory. Certain particulars compiled in 1913, giving a figure of 40 million tons, have often been quoted as giving the total of canal tonnage, and it is this figure, not the comparative figures for 1908, 1905 and 1927 correctly quoted by Mr. Cadbury, which contained the duplications to which I referred. The Ministry's adjusted total figure for 1913 was 23,900,000 tons).

Colonel F. Rayner, Member of Council, said it would be well to emphasise that one of the advantages of water transport not specifically mentioned in the paper was the right of the manufacturer or trader to put on to the river his own craft, absolutely under his own control—self-propelled if so desired—able to come and go when and where the owner wished. Those craft were strictly comparable to the C licence vehicle on the road.

He was in agreement with Mr. Cadbury's views respecting the costing which was carried out by the Severn and Canal Carrying Company. There was a somewhat similar system on the Trent. The railways had stated it was impossible to prime cost traffic. No doubt it was more difficult for the railway companies than for the waterways, but in the case of the latter it was quite possible to know approximately where the line fell between an economic and an uneconomic rate.

The author had given a somewhat qualified estimate of the value of the work of the Rail-Water Conference. Those who were closely acquainted with the origin and working of that agreement and knew something of the follies and extensive cuts in rates even when such an agreement existed, would be very interested to learn of the state of affairs in France, where in spite of much stricter public control of transport similar troubles had been experienced.

He was in cordial agreement with the author's remarks as to the necessity of bringing the waterways to a modern standard. Many of the waterways of Great Britain were a disgrace, including some of those which were carrying a considerable traffic, and it was most desirable that every effort should be made by the waterways to keep on improving their systems and to pay attention to maintenance.

Mr. Cadbury had referred to possible Government assistance. The most appropriate way in which to bring about any assistance of that kind would be on the lines of what had been done not long ago in connection with railway development, when the railways had issued Government guaranteed stock on which they had to pay interest for the purpose of improving, developing and enlarging the efficiency and capacity of the British railways. This policy might well be considered in connection with the development of the waterways of this country. The raising of capital for improvement and development of waterways must, in the financial position of a good many of them, be a very difficult matter. Concerns which were quite sound and which were more than paying their way might not be very tempting for the ordinary investor, but with development there could be no doubt that a more satisfactory result could be obtained.

The author had referred to some of the difficulties which carriers on the railway-owned canals experienced in regard to bye-laws and regulations, and that was indeed a grave matter. He had met cases where railway companies had refused to make any concessions, although it was highly important that very urgent traffic should pass through some lock, for example, during a prohibited hour. Even though the railway authorities were not asked to perform any service, objections were raised.

The efficiency and economy of traffic being put direct overside the ship into small craft were important. At those ports where there were efficient navigable waterways it was possible

* The Paper was reproduced in the February and March issues of "The Dock and Harbour Authority."

The Economic Future of Canals—continued

to give the ships a much quicker turn-round, and it was a great advantage to a port to have efficient waterway connections.

In the paper references were made to future methods of administration. He (the speaker) had contended for years that there should be some system of administration in this country which would make the waterways more valuable and efficient than they were at present. He had given evidence before the Chamberlain Committee and had always been in entire accord with its recommendations. Unfortunately, they had not led to as much as could be wished, but that had been largely due to the inability of the canal and navigation companies voluntarily to go in for large schemes of co-operation and co-ordination. The Grand Union scheme was the only one on a large scale. On the Trent some progress in that direction had been made. Some years ago the Newark Navigation (which was a separate undertaking and practically the property of the town of Newark) had been taken over on a long lease, and recently there had been accomplished what had previously been regarded as impossible. The Trent Company was continually having friction with the railway company which owned one or two of the local canals in the Nottingham district. It was evident that, owing to changes which had taken place in the development of road transport, some portions of these canals hardly justified the loss which was being incurred on them by the railway company. The Trent Company therefore came to an understanding with the railway company not to oppose the closing of certain agreed lengths where there was almost an entire absence of traffic if the railway company would convey to it on economic terms, to be ascertained by mutual agreement, such portions of the canals as were of importance in through navigation. Parliament had this year sanctioned that procedure, and the transfer had been effected. That might form a useful precedent for canals in other neighbourhoods.

He joined issue with the author on his suggestion that the navigation rights and control of the rivers should be handed over to Catchment Boards. He had had experience of Catchment Boards which were controlled entirely by the Land Drainage Act of 1930. There was no representative of navigation interests upon them, and they were under the control of the Ministry of Agriculture and Fisheries. He had been connected with inland navigation for a great many years, and he could give the assurance that those responsible for it would have been very greatly hampered if there had not been government departments trained in questions affecting waterways who were able to advise and to help them, and perhaps to correct any proposals which were not entirely in the public interest. He referred particularly to the Ministry of Transport and to the Mercantile Marine Department of the Board of Trade. He had had numerous dealings with both those departments, and he would rather be under their jurisdiction than under that of the Ministry of Agriculture and Fisheries, which was not concerned with transport or shipping.

He did not say that he would not favour some scheme by which those navigation interests were transferred to some form of board, but it must be a board which would be representative of the government departments to which he had referred. He was strongly of the opinion that, in any sound hydraulic engineering works, navigation interests and land drainage interests should march together. On the Trent the greatest regard had always been paid to land drainage, long before the catchment boards were thought of, and it was in his view essential that these rights, if they were handed over to some form of conservancy board, should not be exclusively under the jurisdiction of the one Ministry which was not concerned with navigation and transport.

Colonel J. A. Saner, Member, said the Weaver Navigation was an example of the advantages of a navigation which was controlled by a public trust. Originally there were 105 county magistrates who controlled the river, but that number was reduced later by the Act of 1896, and now the river was controlled by a body composed of 22 county councillors and 14 toll payers. That seemed to point to the fact that Mr. Cadbury's suggestion of having the same board for the catchment area as for the navigation would be a sound one.

In 1905 and 1906, when giving evidence before the Royal Commission, he had advocated a Waterways Board which would control the whole of the waterways of the country assisted by sub-committees controlling the four arms of what was then known as " the Cross "—i.e., the catchment areas of the four estuaries, the Thames, the Severn, the Humber and the Mersey. The great difficulty which existed in those days and which still held good was that a very large proportion of the canals, especially in the north-western area, were owned and controlled by the railway companies, which for some reason had not thought fit to come into any such scheme.

To-day there was in existence the Central Electricity Board, and a great many of the roads had been brought under State control, so that the suggestion to which he had referred did not now appear so radical as it did at the time when it was first made; it was now a matter of practical politics. If that suggestion were adopted, and if at the same time certain of the canals and main rivers were improved, it would very soon be found that the inland waterways would be a very great convenience, not only in relieving the roads but also because of their strategic importance in case of any military action being necessary. He was sure it was a practical possibility to control the canals by the State, in the same way as the State was now controlling other fields of activity.

Dr. Brysson Cunningham remarked that it was curious to notice the shifting of views which had taken place in the various investigations into the question of the canals. The original Royal Commission was in favour of a Central Waterways Board, whereas the Departmental Committee favoured Regional Committees. The Transport Commission favoured voluntary amalgamation where practicable, and now, judging by the general trend of the paper, Mr. Cadbury seemed to be rather in favour of individual development.

The proposal that the Catchment Boards should take over the management of river navigation interested him professionally. It so happened that he was engineer both to a land drainage authority and also to a navigation authority. He was able, therefore, to compare the functions of the two bodies, and the conclusion to which he came was that it would be inadvisable to bring navigational interests under the control of the Catchment Boards. The outlooks of the two parties concerned were entirely different. The Catchment Boards as drainage authorities wanted to dispose of water, whereas the navigation authorities wanted to make use of it. For the purposes of administration of a catchment area, one naturally looked to the landowners, the farmers and others interested in agricultural matters; in the case of navigation, it was necessary for the commercial and industrial interests to be fully represented. Although it was possible that there might be no serious divergencies of opinion, let alone antagonism, the outlooks were nevertheless different, and it would be difficult to combine them satisfactorily, seeing that the two authorities came under distinct Ministries. It would obviously be inappropriate for the Ministry of Agriculture to have control over, or to influence in any way, decisions reached in regard to navigation.

Unless, therefore, Mr. Cadbury could adduce stronger reasons in support of his proposal, he would view with suspicion any attempt to bring navigation authorities under the control of the Catchment Boards. He thought the Catchment Boards had quite enough to do in looking after the drainage of the country, and they should leave navigation questions to those best qualified to attend them. Whilst he was cordially in sympathy with the movement for doing something to bring the canals into a really efficient condition, instead of merely talking about them as had been done for the last thirty or forty years, he did not think that the plan outlined by Mr. Cadbury, at any rate in the foregoing respect, would bring about the desired result.

Mr. D. Ross-Johnson, a Vice-President, said that Mr. Cadbury's suggestion in regard to Catchment Boards was new and seemed to him well worth examination. He thought that the idea of two or three Government departments being antagonistic and necessarily fighting each other—if it ever existed—was a matter of the past. In India there was a very big Irrigation Department, which had for a century or more managed to combine the duties of looking after the water and spreading it properly in irrigation with the duty of taking care of the navigation, and that department had always, he thought, held the balance equally between the two. He did not see why it should not be equally practicable in this country to have a government department which would hold the scales evenly whether it was done through catchment areas or by regional boards or by a national authority.

There was, however, one point which had not been referred to in the discussion, but which he thought was of considerable importance. Unfortunately, nowadays it had been found necessary to prepare for the possibility of war, and it had been stated that, as the ports would be so vulnerable, provision should be made for inland storage depots for the food supplies and other essential supplies of the country. If those depots were established, it would obviously be necessary to keep them continuously fed. There were still many people who could remember the appalling state of congestion of all the principal ports of the country during the war, and who would remember also the congestion on the railways and on the then existing roads. One of the difficulties was that the whole burden of the imports fell on the eight or nine major ports, while the minor ports of the country were hardly used at all. With an efficient development of the principal waterways and canals, however, those minor ports would be able to take over a great deal of the import tonnage of the country, thus greatly reducing the congestion and the difficulties which had been experienced during the last war.

Although the roads had greatly been improved, he thought that if there were a heavy war traffic, both of imports of food and for supplying the continuous demand which would exist

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for war material to be exported, particularly if there was an army overseas, there would inevitably be congestion on both the roads and the railways, and if the waterways were set apart to supply the inland food depots and maintain a continuous stream of traffic, that alone would justify the cost of putting them in order.

It would be of interest to see what the cost would be at the present time of improving the canals. The Royal Commission in 1906 had estimated that it would cost between £16,000,000 and £17,000,000 to put the whole of the canals on a 100-ton standard, a figure which excluded the actual cost of acquiring the undertakings. That figure would have to be revised to-day, but not alone in an upward direction. In the first place, it was now common ground, as Mr. Cadbury had pointed out, that certain of the inland canals could not economically be raised to a 100-ton standard, and also, of course, the Grand Union Canal had solved about a quarter of the whole difficulty. A further consideration was that to-day £16,000,000, or even £20,000,000, could not be looked upon as a very large sum of money. The London Passenger Transport Board had schemes in hand costing £45,000,000 for the area round London alone. To afford such an enormous relief to the general transport requirements of the country as the canals would—in the opinion of a great many people—afford, an expenditure of £20,000,000 would be well worth while.

Mr. George Dallas (Chairman, Nene Catchment Board) said that, in view of his position, he might be forgiven for taking an entirely different point of view from that of Colonel Rayner and some of the other speakers. The Catchment Board of which he was Chairman was not only a board brought into existence under the Land Drainage Act of 1930, but was also the Nene Navigation Commission, which dated back for a hundred years or so. The Board combined by law the duties and the responsibilities both of land drainage and of navigation. It had been his duty to discuss both these matters with the Ministry of Transport, the Board of Trade and the Ministry of Agriculture, and conferences had sometimes been held at the offices of one or the other with departmental representatives of all present. There had never at any time been the slightest difficulty, and he did not understand why Colonel Rayner should think that because part of one's duties came under one Ministry and part under another it would lead to a great deal of trouble and ill-will, as well as friction. That had not been his own experience; he would view it very seriously, so far as his own river was concerned, if the navigation of that river were under some other body altogether.

By law the duty of maintaining the banks had been vested in the Catchment Boards. If some other body were looking after the traffic which had no responsibility for the banks, it might, in his judgment, sometimes lead to considerable difference of point of view, if nothing else. He did not know whether that had happened on the Trent, but he could visualise that it might happen in his own case, and therefore he was very happy to say that his board had the responsibility both for navigation and for drainage.

Colonel Saner was mistaken in thinking that the sole duty of a Catchment Board which had no responsibility for navigation was to dispose of the water. That was not so; it was equally incumbent on the Catchment Board to preserve water as well as to get rid of it. He saw no conflict, therefore, in such a body having to look after the water both for navigation and for drainage.

His Board was carrying out on the Nene, as the author had mentioned, some very large works. The navigation on the river had almost disappeared; the waterway had got into as dilapidated a condition as could be imagined, but the Board was reconstructing the whole of the locks from one end of the river to the other, and was widening and deepening the river, and he hoped that a few years hence it would be made a very good river for navigation. At the present time the Board was almost bombarded by enquiries from carriers as to when it would be possible for them to carry traffic on the river.

Mr. H. W. J. Powell (L.N.E. Railway) said that as a surveyor to a railway company he had been particularly interested in the summary at the end of the paper, and especially in the author's statement that the ownership of the waterways required investigation with a view to the elimination of railway interests. He thought that Mr. Cadbury had put the point very fairly, if somewhat bluntly. The Company he served were the owners of quite a large number of canals. They had not yet been approached by anyone, but they would welcome any approach and would be happy to negotiate the sale or the lease of their interests in these canals, subject, of course, to the approval of Parliament.

With regard to the Catchment Boards, he thought that one point had been overlooked. If it was desirable that the Catchment Boards should control the navigation on canals, it should be borne in mind that they had also the power to levy rates to cover the costs entailed in their work. It would be necessary to consider whether an authority which had the right to precept and levy rates was the proper body to control navigation and therefore trade in competition with other forms of transport.

Mr. E. G. Garstang, Member, remarked that he was not at the present time concerned with any navigation authority, but was on the staff of a railway. He thought it would be utterly unfair to consider any policy for the national funding of canals without first considering the position of the railways. The railways had compulsorily bought canals, and might, thereafter, naturally and reasonably have adopted a policy which had attracted more business to their own concern as railways than to the canals they had so acquired. It must, however, be remembered that what the railways had bought they had paid for, and therefore they had just as much right to look for support in any national scheme for the funding of transport undertakings as had the canal system of the country.

While he was in agreement with what the author had said of the excellence of the continental canal system, it should be pointed out that the development of many of those canals was due largely to the ordering or systematising of many of the deltas of the large rivers. The New Waterway in Holland and the various rivers round the Elbe and the Weser were practically the result of the canalisation of the different waters of those rivers which, for the salvation of the country, had been kept to certain channels and which, after a time and with the growth of commerce, had become valuable commercial transport assets. In this country the railway and road systems were so excellent and intricate that, whilst there was room for certain of the canals to live, and even to be improved, he would suggest that the transport requirements of the country generally could, with those few exceptions, adequately be met by a properly combined railroad policy, to the exclusion of the expenditure of any tremendous amount of national money on what were to-day, in many cases, derelict canals. None of his remarks referred to those waterways at present well-administered and which served a useful purpose in the life of the country.

Mr. W. Tetley Stephenson, Member *[Communicated]*:—The author raised a point of exceptional interest and of wide application, when he pleaded for inland waterways to be considered not merely in their capacity to show profits, but as an essential part of a public service regarding which the benefits to the community of cheap transport should be set against any failure to earn an adequate return on the capital. This is one of the big issues in transport generally to-day. Unaided British shipping has to compete against foreign shipping, subsidised as a public service. British ports have to compete with near continental ports under similar unequal conditions. Traders may make unfavourable comparisons between inland transport charges in this and European countries, and the explanation lies in the amount of cost paid out of public funds in the latter. The matter is primarily one of national policy and is not peculiarly a matter of inland waterway transport. When the policy is determined, it should be of general application. Road transport would certainly benefit least. Railways would benefit as much, probably more, than inland waterways since certain inland waterways, e.g., the Manchester Ship Canal and the Trent Navigation, have been subsidised out of local rates and thereby had an advantage. Like treatment is essential for the " future " to deserve the qualification of "economic." On the basis of equal treatment, it is difficult to find in the paper ground for anticipating that inland waterway transport will increase its share of the traffic.

The bulk of the paper constitutes special pleading for inland waterways. So far as certain but not all river navigations are concerned, a case can be made out. The Rhine would be a way for cheap transport even if all the costs were thrown on the traffic. As regards canals, the author had made out no case, and the writer maintains that only in very special circumstances can a case be made out. The author invariably refers to Europe but never to the United States. But he must be aware that the magnificent New York State Barge Canal costs the New York State so much annually that the State would be in pocket if all the traffic on it were carried by railway and the whole carriage charges paid by the State, whilst traders would get free transport instead of paying carriers' charges. In Belgium and Germany investigations carried out by the writer showed that the differences in the carriage charges by railway and canal were entirely explained by the differences in the amount of the costs paid out of taxes. In France, where the difference in subsidisation was less, the canals were unable to hold traffic against the railways until through public control of railway rates a minimum difference of 20 per cent. in favour of the waterways was insisted upon. In other words, the consumers' choice was limited by regulation that there might be a sufficient traffic on the canals to save the faces of the politicians. In the opinion of that eminent French savant and economist, M. C. Colson, Inspector-General of Roads and Bridges, "three-fifths of the expenditure on the canals of France had been a

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pure waste of public money." This appears as true to-day as when the opinion was expressed.

The Author's Reply

Mr. George Cadbury, in reply, said he had been greatly interested to hear some of the criticisms and remarks which had been made. He only regretted that more of those concerned with the railways had not spoken, and he was especially glad, therefore, to hear Mr. Garstang's remarks, to which he would like to refer briefly later.

The Chairman's question about the tonnage basis was one to which he could not give a perfectly clear answer. He believed that the returns were divided into two categories, the general water-borne tonnage and the originating tonnage. He had been careful to take the originating tonnage as the basis of his remarks, because the other tonnage might be multiplied several times when travelling over several waterways, and he felt that it was not a very adequate figure to quote. He had not ascertained exactly, however, what the figures were which the Royal Commission gave.

He accepted at once Colonel Rayner's statement that one advantage of water transport had been omitted in the paper, namely, the right of the trader to put his own craft on the waterway very much as the owner of a road vehicle could put his vehicle on the road. That was an important point which should have been mentioned.

Several speakers had referred to the question of the Catchment Boards, and some appeared to be in agreement that a single authority would be an advantage. Dr. Cunningham, who questioned the advantage of having one board, said that at present it was the duty of one authority to dispose of the water and of the other to conserve it. Now, there was only one lot of water in the river; it could not be divided, one part of it being got rid of and the other being conserved; and that lent force to the argument that there should be one authority which had to take the water as water and deal with it so that the best possible use should be made of it. On the River Severn there were three bodies—the Severn Commission, the Catchment Board and the Fisheries Board. They all had their say as to how the water should be dealt with, and it was marvellous that any progress was made at all. It was quite possible that the Catchment Boards, as they existed to-day, were not necessarily the ideal bodies to deal with navigation, but some single body to deal with the river as an entity was essential if the best use was to be made of the river, both as a drain for taking away floods and a system of navigation for traffic, and as a water supply for the cities on its banks. He was still of opinion that one single authority was the only really practical method of dealing with the matter in the case of any river, and he was glad to hear agreement expressed with that point of view.

He would like briefly to deal with the position of the railways. The railways acquired many of the canals under compulsion and against their will. They did not buy them as an investment. The canal companies took fright in the railway era, and made it a bargain that if a certain railway was built the railway authority should buy the canal and guarantee it. That had occurred in many places all over the country, and he believed that most of the canals which had been acquired by railways were acquired in that way. They had always been a liability to the railways in consequence, and the railways did not want them and felt that they upset their own system and were unduly competitive; and, as the figures given in the paper showed, generally speaking, the railways had taken a negative or even a hostile attitude to these waterways, and certainly had not encouraged them. Colonel Rayner had pointed out that they could even be quite obstructive on occasion, and, personally, he knew of many cases which showed that the railways were not primarily interested in developing traffic on the waterways, to put it no higher than that.

That being the case, those who thought that the waterways had a future realised that it was inevitable that the dead hand must be removed from those important links of waterway which the railways at present held. He thought it was to the railways' own interest that they should take their hands off these waterways. The railways had better do their own job and leave the waterways alone.

With regard to the question of whether the road and the rail could carry all the traffic, so that it was not necessary to consider the waterways, he was certain that in the next four or five years there would be a degree of development on the waterways which many people did not expect. He had been talking the matter over with people who were interested in waterways and who had traffic to put upon them, and he felt that there was an immense amount of traffic ready to flow along those waterways as soon as the necessary facilities were provided. It was impossible to say that that was not going to be of advantage to the community. If the waterways could take anything up to 100-ton boats, and in certain cases up to 400-ton boats, they were bound to be able to convey traffic much more cheaply than any other method of transport, and it was going to relieve the congestion on the roads. It was already being said that the Ministry of Transport was going to be faced with the problem of providing enough roads for the vehicles which were being produced, and that that was going to be a big expense. He would like to see investigated the question whether it would not be cheaper to modify and develop some of the waterways with that money, rather than spend it on building Autobahnen such as were being built in Germany, which would be of very doubtful value in this country. The country might be forced to consider what was the best method of spending the money to cope with the increasing traffic, and at comparatively small expenditure the canals could be developed in such a way as to relieve the Ministry of considerable expenditure in expanding the roadways. While the railway and the road transport undertakings might think that there was no need for the waterways, he felt that in some cases the wish was father to the thought, because he felt sure, from what he knew, that there was going to be a very considerable development of water-borne traffic, and that the waterways would meet a need which neither the road nor the rail could possibly meet.

Staff Changes and Appointments

The Port of London Authority announce that Mr. Asa Binns, M.Inst.C.E., M.I.Mech.E., will retire from his present position as their Chief Engineer on the 1st May next, and that Mr. W. P. Shepherd-Barron, M.C., T.D., M.Inst.C.E., has been appointed Chief Engineer from the same date. Mr. Shepherd-Barron is at present Special Assistant to the Chief Engineer, and prior to taking up this appointment last year he was Chief Engineer, Karachi Port Trust. Mr. F. W. D. Davis, M.Sc., M.Inst.C.E., now Chief Assistant Engineer, has been appointed Deputy Chief Engineer as from the 1st May. The Authority have recorded their appreciation of the long and valuable services rendered to them and their predecessors by Mr. Binns, who, in future, will be associated as a consultant with Messrs. Rendel, Palmer & Tritton, of Westminster, and will continue to be at the Authority's disposal in the capacity of Consulting Engineer.

The Tyne Improvement Commission have appointed Mr. A. L. Harvey, M.C., B.A., Assoc. M.Inst.C.E., as Assistant Engineer to Mr. R. F. Hindmarsh, M.Inst.C.E., the Chief Engineer. Mr. Harvey has had experience in harbour works at Vancouver, B.C., St. Johns, Newfoundland, and Chicoutimi, Quebec, as well as in this country, where he has acted as Resident Engineer on several important undertakings.

The appointmet of Mr. Warren J. Bruce as Assistant Docks Manager of the Manchester Ship Canal Company, has been confirmed by the Board. Mr. Bruce joined the Company in 1894, the year the canal was opened, and has had experience in all the operating departments of the undertaking.

Obituary

The death on March 11th of Mr. Hugh Henry Gordon Mitchell, O.B.E., V.D., M.Inst.C.E., will have occasioned in harbour and port circles a sense of great loss. Mr. Mitchell, for the past 17 years a partner in the firm now known as Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, MM.Inst.C.E., was throughout his professional career mainly associated with harbour construction and administration, having been engaged on various undertakings at Dover, Colombo, and in East Africa, but chiefly as Harbour Engineer at Madras from 1905 until 1919, when he succeeded the late Sir Francis Spring, K.C.I.E., as Engineer-Chairman of the Port Trust, and had to deal with the rehabilitation of the harbour after a disastrous cyclone. From 1920 to 1922 he was a representative for India on the Council of the Institution of Civil Engineers.

The announcement has also been received with regret of the death, on 28th February, of Mr. G. Lorenz, lately Chief Engineer of the Port of Copenhagen. Mr. Lorenz was born in 1865, and completed over 40 years' service with the Port Authority. He was a member of the Board of the Danish Association of Engineers, and from 1913-19 Chairman of the section for road-making, hydraulic engineering and railway building. He was responsible for the carrying out of extensive harbour improvements, also for the erection of numerous movable bridges across the harbour and for the improvement of its canals. He was an excellent administrator and carried out, with great energy, the important tasks entrusted to him.

The Port of New York Authority

Construction of the Lincoln Tunnel under the Hudson River

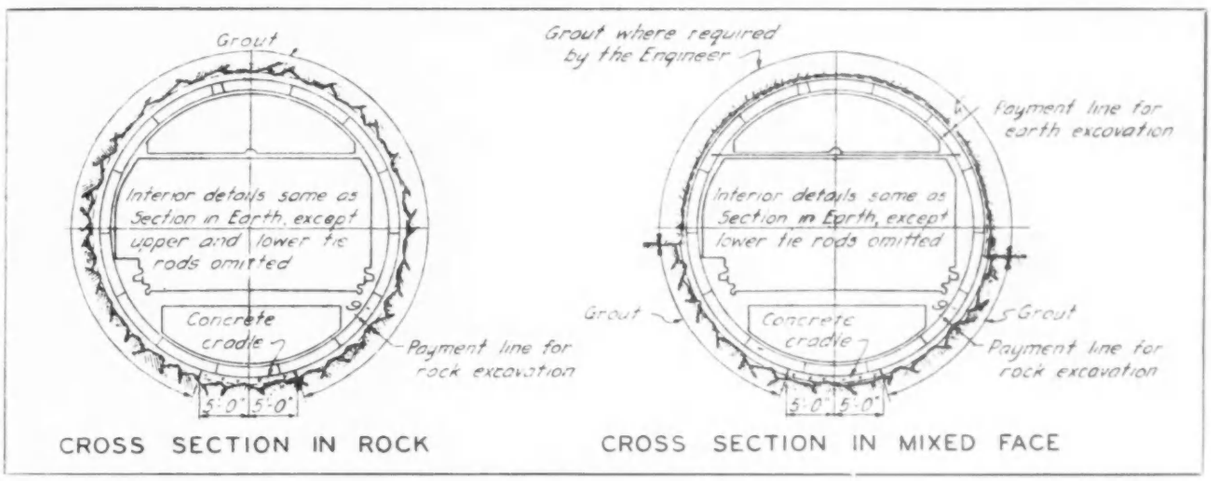
(CONTRIBUTED)

The Object of the Tunnel

TO avoid a return to the almost continually congested condition of cross-river traffic that existed before the Holland Tunnel was built, The Port of New York Authority is constructing the new Lincoln Tunnel to serve the area between " downtown " Manhattan and Washington Heights.

The new tunnel extends from West 39th Street and Tenth Avenue, Manhattan, to Weehawken, New Jersey, where (by means of an express highway) it will connect with all important traffic arteries in the area. On the New York side it could eventually connect with a future crosstown Manhattan tunnel and, by it, with the new Queens-Midtown Tunnel, which is being built by the New York City Tunnel Authority, a New York City body not connected with The Port of New York Authority. The Queens-Midtown Tunnel is to run under the East River from about East 38th Street, New York, to Long Island City. Through these three tunnels a direct route would be provided between New Jersey and Long Island as well as Manhattan.

The Port of New York Authority, which is building the Lincoln Tunnel, is a bi-state organisation, created by compact between the States of New York and New Jersey, for the purpose of developing the transportation facilities of the port.



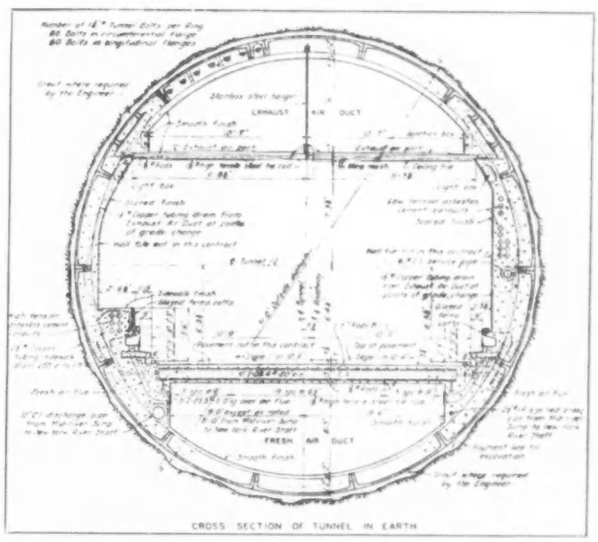
History of the Lincoln Tunnel Project

A Hudson tunnel in the midtown area had been discussed for many years, the first engineering studies having been made jointly by the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission while these bodies were still constructing the Holland Tunnel. In January of 1931, The Port of New York Authority reported, as the result of its own studies, that this facility was needed and that it could be financed upon a self-sustaining basis. Shortly after this, the two States established certain policies regarding interstate crossings within the port area and merged the two Tunnel Commissions with the Authority, vesting in this body the control and operation of the Holland Tunnel. At the same time, the Authority was authorised and directed to proceed with construction of the new tunnel. When construction was started the Lincoln Tunnel was called the Midtown Hudson Tunnel, but some confusion arose when the name of Queens-Midtown Tunnel was adopted for the City's East River vehicular tunnel. On April 16th, 1937, the Port Authority officially adopted the name " Lincoln Tunnel " for its Midtown Hudson Tunnel, the name of " Dyer Avenue " for the south tube approach street at the New York end, and the name of " Galvin Avenue " for the corresponding north tube approach street.

Financial Arrangements

Early in 1931 arrangements were made to market the tunnel bonds while engineering studies were under way and certain necessary real estate was acquired. Several months later these arrangements were slowed up by the general business depression, and work had to be suspended in 1932. Later, upon application for a loan to the Federal Emergency Administration of Public Works, the Authority, on September 1st, 1933, entered into an agreement with the Federal Government, under the terms of which 4 per cent. bonds of the Authority up to a total of $37,500,000 were to be purchased by the Federal Government to finance the First Operating Unit of the project. This consists of one of the two under-river tubes with corresponding approaches on each side of the river.

Due to improvement in business conditions, the Authority found it practicable to issue certain of its General and Refunding Bonds in March and again in December of 1935. All Federal advances were repaid and, in addition, capital obtained to complete construction of the First Operating Unit of the tunnel. In January, 1936, the loan agreement with the Federal Government was modified to provide for the release of the remaining Federal funds which had been allocated to the project for loan purposes. A grant of $4,700,000 was provided to construct certain westward extensions of the New Jersey approaches which were not originally included as part of the First Operating Unit. Toward the closing months of 1936, traffic on the Port Authority's existing facilities was increasing at a rate which warranted an immediate start upon the second, or north, tube of the Lincoln Tunnel.

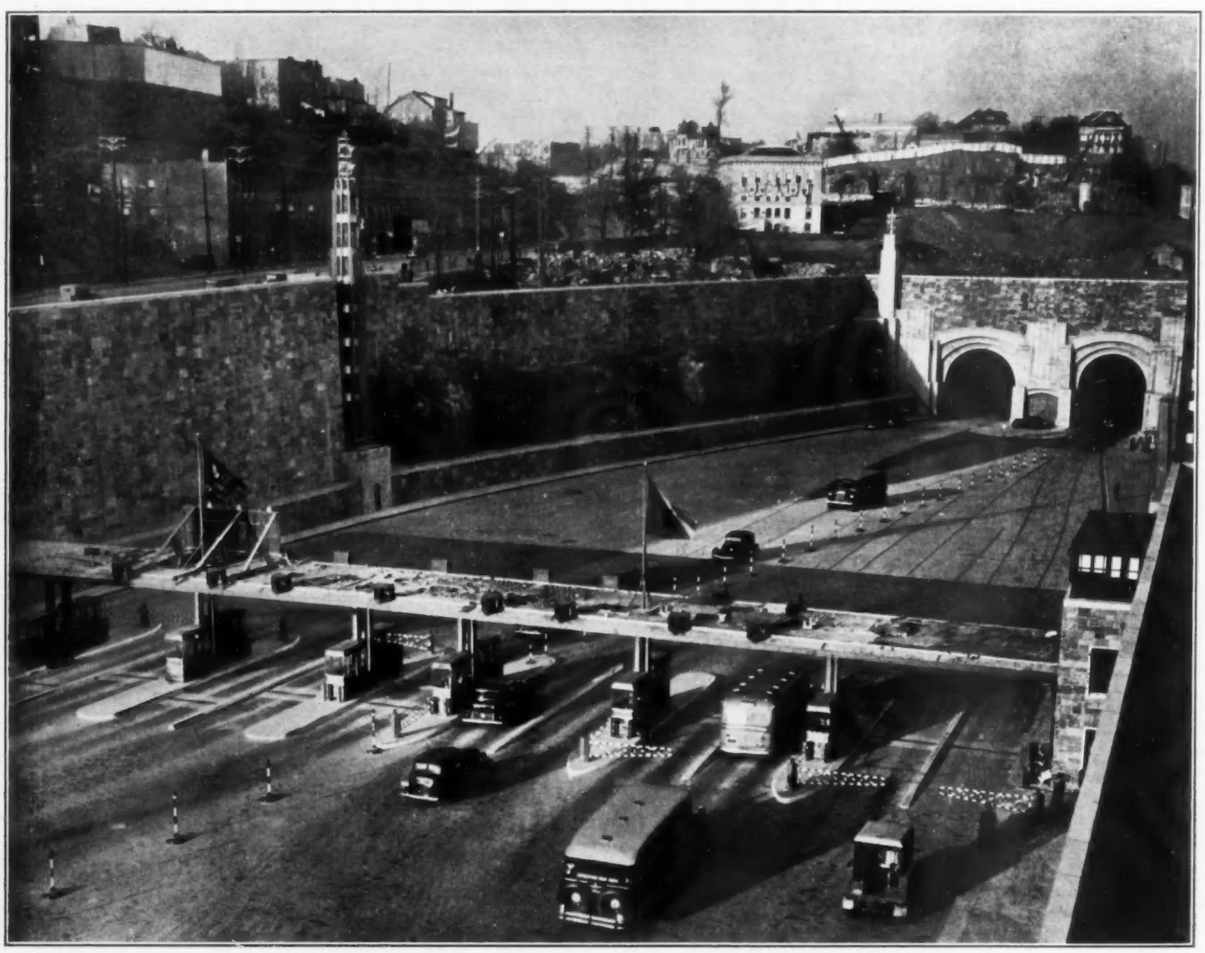


CROSS SECTION OF TUNNEL IN EARTH

Hence, on November 24th, 1936, the Commissioners of the Authority, with the approval of the Governors of the two States, authorised its construction. A Fourth Series of 3 per cent. General and Refunding Bonds was floated in December of 1936, from the proceeds of which the sum of $10,000,000 was made available to begin construction of the second tube of the tunnel. In August of 1937, a Fifth Series of 3¼ per cent. General and Refunding Bonds was disposed of, and about

Lincoln Tunnel, New York

Eastbound Bus passing Westbound Passenger Car in the Lincoln Tunnel near the New Jersey Portal.



General View of the Weehawken, New Jersey, Plaza, showing Toll Booths and Portals.

Port of New York Authority—continued

$11,306,000 of the proceeds were apportioned for construction of the second tube. Early in October, 1937, the Federal Emergency Administration of Public Works made available to the Authority a loan of $26,000,000, to be called on if needed, for carrying on construction. Under the same agreement, the P.W.A. extended to the Authority a grant of $3,100,000, to be applied to labour cost.

General Arrangement and Construction

The complete project will consist of two separate tubes, each with a double-lane roadway. Work on the First Operating Unit of the tunnel, consisting of the south tube of this pair and corresponding portions of the approaches and ventilation system, was begun in 1933 with the start of manufacture of the cast-iron tunnel segments. This tube will carry both east-bound and west-bound traffic until the second, or north tube, and the remaining portions of the approaches and ventilation system are completed. Such arrangement will afford some traffic relief at a considerable earlier date than would have been possible had the Authority delayed construction of the south tube to permit constructing both tubes simultaneously.

Construction of the tunnel itself was begun in March, 1934, and this first, or south, tube was "holed through" under the river on August 2nd, 1935; work has continued steadily since, and this initial unit was opened for traffic early in 1938. In the meantime, construction of the second, or north, tube with its corresponding extensions of the approaches, has since been started, and this tube is expected to be ready for operation in the latter part of 1940.

New York Approach

The New York end of the First Operating Unit of the Lincoln Tunnel will include a surface roadway for tunnel traffic, which extends from West 34th Street to West 42nd Street, near the middle of the blocks between Ninth and Tenth Avenues, and substantially parallel to these thoroughfares. Direct connection will be made with West 34th, 35th, 36th, 40th, 41st and 42nd Streets, permitting diffusion of traffic over such a large area that operation of the tunnel should create no undue traffic congestion in the city streets. In the few initial years of operation, pending completion of the north tube, this approach will serve as both entrance and exit. In connection with the construction of the second, or north, tube, another surface roadway will be constructed in the blocks between Tenth and Eleventh Avenues, running from West 37th to West 42nd Street. This roadway will be constructed above the New York Central Railroad's right-of-way, and direct connection will be made at grade with all streets from West 37th to West 42nd Street, inclusive. Upon completion of the north tube, it will carry only west-bound traffic and the first, or south, tube will carry only east-bound traffic.

The location selected for the tunnel and the arrangement of its approaches on the New York side will permit access to and from the ramps of the West Side (elevated) Express Highway as well as the city's crosstown tunnel. Through this crosstown tunnel it will, in turn, connect with the tubes which the City is now building under the East River to Queens.

New Jersey Approach

Toll collection facilities will be located in Weehawken, where connection will be made with Willow and Park Avenues to the south, and Hudson County Boulevard East to the north. Plans for the New Jersey Approach provide connection with all important highways east of the Palisades plateau. An express highway will extend across the plateau of the Palisades as a depressed roadway, passing under all north and south streets and making connections with Hudson County Boulevard West and with the State highway arteries west of the Palisades. Marginal surface streets will be provided on each side of this new express highway through Union City.

Details of the Main Tunnel

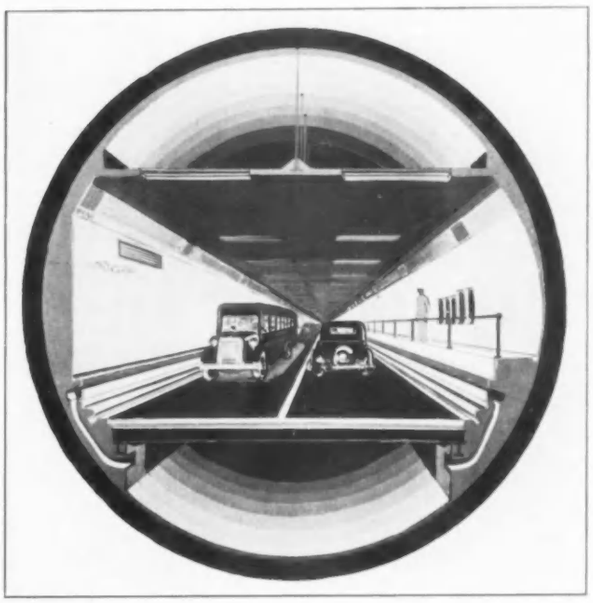
The total portal-to-portal length of the south tube of the tunnel is 8,215-ft., including cut-and-cover construction extending for distances of about 240-ft. in New Jersey and about 560-ft. in New York. The total portal-to-portal length of the north tube will be about 7,400-ft., including some cut-and-cover construction at each end.

These cut-and-cover sections are of the steel-bent types similar to the usual subway construction, and are rectangular in section. The remaining sections are constructed by tunnelling methods (as distinguished from "cut-and-cover" work), and throughout these the bore is circular. In the river sections from the New Jersey ventilation building to the New York land ventilation building at Eleventh Avenue, a distance of 6,180-ft., each tube will be formed by a shell of cast iron or cast steel segments with an outer diameter of 31-ft. This shell is made up of rings 30-in. long, and each ring consists of 14 large segments and a smaller key segment. The large segments weigh about 3,100 pounds each.

In addition to the river tunnel, which for the most part passes through Hudson River silt, there are about 1,200-ft. of circular tunnel of the south tube passing through rock on shore. About 750-ft. of this rock tunnel is in New Jersey, immediately west of the ventilation building, while another 450-ft. runs east from the New York land ventilation building. Corresponding sections of somewhat different length will be constructed as parts of the north tube. The outer diameter of the rock tunnel shell, made up of structural steel segments instead of cast segments, is 32-ft. 10-in. in New Jersey and 30-ft. 4-in. in New York. The New Jersey portion and the under-river portion of the north tube will be practically the same as the corresponding sections of the south tube, but the New York portion will be considerably shorter, due to the approach plan.

Roadway and Interior of the Tubes

At the low point, at approximately mid-river, the top of the tube structure is about 75-ft. below mean high water, and the roadway is about 97-ft. below. At present channel depths, a minimum covering of 20-ft. of silt and mud will be left permanent above the completed structure at all points. The north tube of the project will approximately parallel the under-river course of the south tube, and will lie about 75-ft. north of it, as measured between the centres of the two. The inside of the cast iron and cast steel tunnel shell is lined with concrete to a minimum thickness of 16-in. as measured from the outside of the structure.



Pictorial Cross-section of one tube of the Lincoln Tunnel.

In the circular tunnel a concrete floor slab incorporating steel beams supports the roadway, and the space below it forms a fresh air duct. A ceiling, formed by a reinforced concrete slab, encloses the upper portion of the tube to form the vitiated air duct. The whole arrangement is very similar to that of the Holland Tunnel. Throughout the river portions of each tube the finished roadways will be 21-ft. 6-in. from curb to curb, or about 18-in. more than that of the Holland Tunnel. In a curved portion, at the Weehawken end, this curb-to-curb clearance will be increased to 24-ft. Headroom in the roadways will be approximately 13-ft. 7-in. throughout, permitting safe operating clearance of 13-ft.

Electrical ducts are enclosed within the concrete of the side walls as these are constructed. Lighting, fire protection, communication, traffic control and other equipment will closely resemble that of the Holland tubes.

Ventilation System and Buildings

The ventilation system of each tube is divided into several sections, and is patterned after that used in the Holland Tunnel. The space below the roadway in the circular tunnel forms the fresh-air duct, and the space above the tunnel ceiling forms the exhaust air duct. Three ventilation buildings are provided, studies of the economics having shown such an arrangement to be the most desirable for this tunnel.

All three buildings are completed so far as required for operation of the south tube of the tunnel. One building is at the base of the Palisades, another just outside of the New York bulkhead line at the foot of West 39th Street; and the third is at the south-west corner of West 39th Street and Eleventh Avenue, New York. Fresh air will be drawn in through louvers in the side walls, the intake fans being arranged on

Port of New York Authority—continued

different floor levels adjacent to these openings. Exhaust fans drawing the vitiated air from the tunnel are similarly disposed on different floors, and arranged to discharge vertically through evasé stacks extending through the roof of each building.

Construction Progress

The first construction contract, covering manufacture of the segments for the shield-driven tunnel of the south tube, was signed in October of 1933. Actual construction of the tube itself began promptly after signing of the shield tunnel contract in March of 1934, official ground-breaking ceremonies being held on each side of the river on May 17th, 1934. All work has progressed steadily since, and this first tube has been constructed by a tunnelling shield, which was driven through the river bed all of the way from Weehawken and into the New York River shaft caisson. The maximum pressure used in this work was 45 pounds per square inch, this pressure having been

New Jersey Ventilation Building at the foot of Kings Bluff, Weehawken, New Jersey.

required when sealing the bottom of the New York River shaft. Most of the under-river construction required only 16 pounds of pressure. The maximum progress of the tunnelling shield in 24 hours was 45½-ft., a record made on June 22nd-23rd, 1935. The maximum monthly progress was 1,040-ft., made in June, 1935. Concrete lining of this portion of the tunnel and the installation of roadway and ceiling slabs are all completed.

Note on State of Works at beginning of present year, by Mr. J. C. Evans, Chief Engineer.

The First Operating Unit of the Lincoln Tunnel was dedicated with appropriate ceremonies on December 21st, 1937, and opened for traffic at 4 a.m. on the following day. The plaza of the completed south tube, located in the west half of the block east of Tenth Avenue and south of 39th Street, together with Dyer Avenue, the new approach street, extending from 34th Street to 42nd Street, comprise the New York Approach facilities.

In New Jersey, Weehawken toll area, with ramp connections to Hudson County Boulevard East and to Park Avenue, together with the south marginal roadway between Hudson County Boulevard East and Pleasant Avenue, and both north and south marginal streets from Pleasant Avenue to New York Avenue in Union City, comprise the completed portions of the tunnel approach.

At the close of the year, the first portion of the "loop" viaduct structure, which will ultimately connect the south end of the Weehawken toll area with the depressed express highway across the Palisades, was built as far as the east side of Hudson County Boulevard East and the section forming the upper portion of the loop, north of the toll area, from the east side of Hudson County Boulevard East to and across Pleasant Avenue, was about 45 per cent. completed. In December four contracts for the construction of the remainder of the "loop" approach were executed, as was also a contract for excavation for the depressed express highway from Bergenline Avenue in Union City to Prospect Avenue in North Bergen.

The close of the year also witnessed excellent progress on the tunnelling operations for the second tube. The rock tunnel under King's Bluff was completely excavated and was being lined with concrete. Excavation for the New Jersey ventilation shaft was completed, and shield-tunnelling operations had progressed about one-third of the distance under the river toward the shaft of the river ventilation building at the New York bulkhead line. The caisson forming the shaft was sunk to rock and sealed in November. Shield tunnelling under the New York streets was completed on December 22nd, when the shield entered the side wall of the caisson through a hole burned in the steel plates to admit it.

Considered as a whole, the north tunnel contract for the rock tunnel, shield tunnel and shafts was over 50 per cent. completed, the entire operation being advanced several months ahead of schedule. The contract had been let in February, 1937.

The contract for the cast iron and cast steel tunnel lining, awarded at the close of 1936, was practically completed during 1937.

All contracts of the First Operating Unit, except those for viaduct sections of the New Jersey Approach, were either completed or practically so. The work on the Weehawken sections of the New Jersey Approach is scheduled to be finished before the end of 1938 and the entire New Jersey Approach by the summer of 1939. The second tube and its New York Approach are expected to be completed in 1940.

Statistical Data on the Lincoln Tunnel

Dimensions, Weights, etc.

Length of first (south) tube, portal to portal	8,215-ft.
Length of second (north) tube, portal to portal	7,400-ft.
Length of each tube under river	4,600-ft.
External diameter of cast iron and cast steel shell, in general	31-ft.
Minimum thickness of concrete lining inside of iron or steel shell	16-in.
Maximum depth of top tunnel below mean high water	75-ft.
Maximum depth of roadway below mean high water	97-ft.
Minimum covering of mud and silt above top of tube	20-ft.
Distance between tubes under river, centre to centre, about	75-ft.
Width of two-lane roadway, between curbs	21½-ft.
Weight of each cast iron tunnel shell segment, about	3,100 lbs.
Cast iron and cast steel in shell, complete project, about	101,400 tons
Maximum capacity of two-tube project in vehicles per hour, about	4,000 (a)
Normal maximum number of vehicles per year, about	15,000,000

Publications

The Appleby-Frodingham Steel Co., Ltd., of Scunthorpe, Lincs., have issued a brochure setting out the advantages of "Kulpus" mild steel, as a weather-resisting material which possesses greater strength than ordinary mild steel. It is claimed that while "Kuplus" steel is not rustless and non-corrodible, it is considerably more resistant to atmospheric corrosion and is useful in structures exposed to the effects of damp or fume-laden air. "H.T.K.," or High Tension Kuplus, another product of the company, is a high tensile steel, having a permissible unit working stress of approximately 50 per cent. more than mild steel. The booklet gives particulars of tests carried out in support of these claims.

Messrs. Robert Boby, Ltd., of Bury St. Edmunds, have supplied an illustrated catalogue (M.H. 5), showing various kinds of plant and material manufactured by them, including elevators and conveyors, constructional steelwork, pneumatic grain-handling plant, portable conveyors, etc. A number of the views relate to quayside operations.

From the Administrative Council of the Autonomous Port of Havre comes a tastefully-illustrated brochure containing a full description of the port and its various activities, with particulars of the connecting lines of transport by rail, road, sea and air. It is pointed out that the external commerce of the port extends throughout the world. It receives more than half, and sometimes nearly the whole, of the importations into France of cotton, coffee, fresh fruit, pepper, exotic timbers, etc. It is the second port of France in movement of navigation and third in rank for tonnage of goods unshipped.

The catalogue of electric cargo handling and grab cranes recently issued by Messrs. Stothert & Pitt, Ltd., of Bath, contains illustrations and particulars of a great variety of plant supplied by the Company to various dock and harbour authorities, contractors and others throughout the world.

Notes of the Month

Additional Cranes for London Docks.

Twenty-five additional portable electric 3-ton luffing quay cranes are being provided by the Port of London Authority at the docks. The total number of cranes in the Authority's docks is now 1,400, ranging from 10-cwt. runabout cranes up to the 150 tons floating "London Mammoth."

New Dredger for Wellington Harbour, New Zealand.

The single-screw hopper dredger "Kerimoana," built to the order of the Wellington Harbour Board, New Zealand, was launched by Messrs. Fergusson Brothers (Port Glasgow) Ltd., during the early part of last month. The vessel is fitted with steam machinery, and is equipped with most modern auxiliaries. After trials on the Clyde, the dredger will make the voyage to New Zealand under her own power.

Southampton Docks.

The continued increase in the amount of shipping traffic dealt with at Southampton Docks is reflected in the latest returns relating to activities during the early months of this year. Compared with the corresponding period of the preceding year, there was, during January and February, an increase of 12 per cent. in the tonnage of shipping entering the port. Imports and exports of freight have also been heavy recently, the former being influenced by exceptionally large quantities of fruit from South Africa, Palestine and the West Indies.

Tyne Dock Development.

At a meeting of the Tyne Improvement Commission on March 16th, it was reported that plans were under consideration for an improvement scheme at the Tyne Dock, recently acquired from the London and North Eastern Railway Company. The estimated cost was £831,000, and towards this a grant of 33⅓ per cent. had been promised by the Commissioner for Special Areas. The project includes the reclamation of land on the West side of the dock, so that an area of about 40 acres, at present submerged, would become available for dock purposes. For the proposed new quay at the north-west end of the dock, it has been decided to consider an alternative scheme of an 800-ft. length instead of the 700-ft. length originally contemplated.

Port of Marseilles Improvements.

Work on a scheme of improvement, which it is estimated will cost 3,000,000 francs (£20,000), has been commenced on the P. and O. Quay at Cap Janet at the north end of the Port of Marseilles. Two or three large P. and O. liners berth simultaneously at the port every week, and at present the length of quayage is insufficient. Also, passengers, after landing at the first storey of the existing building on the quay, have to descend to ground level in order to enter their train or conveyances; while, on embarking, they have to climb up to the first storey to reach the gangways. Under the new scheme the quay accommodation is to be extended by dredging another 466 yards, so that accommodation will be afforded for three liners, each up to 660-ft. in length. A new station is to be built on the site of the present shed, and on the upper floor, which will have an area of 4,300 sq. yds.; there will be a large Customs Hall, with a bench 100 yds. in length, to expedite the examination of luggage. Passengers will be conveyed to and from their trains by escalators and lifts, while road vehicles will run up a ramp from the road to a courtyard at the rear of the Customs Hall.

Oil Pollution in British Waters.

Among the questions recently asked in the House of Commons was one by Mr. D. R. Grenfell about the conditions under which oil was discharged by harbour authorities in Great Britain; whether uniform methods were employed in disposing of oil residues from tanks; whether separators were in general use, and whether it was proposed to issue further regulations to prevent oil pollution in British waters through failure to convey the oil a sufficient distance from low-water mark when taken out for dumping at sea. The President of the Board of Trade (Mr. Oliver Stanley) replied as follows:

"Separator barges are available at several of the important commercial harbours of this country for the purpose of receiving oily water from vessels, and the recovered oil is either consumed in the ordinary way or is burned under boilers at shore works. There is no uniform method of disposing of the sludge. If it is incombustible it is sometimes dumped on land as ordinary refuse and sometimes taken out to sea and dumped at varying distances from land outside territorial waters. So long as the deposits are not made within territorial waters in contravention of the Oil in Navigable Waters Act, 1922, there is no power to take action; but I am not aware that any pollution of our coasts is caused by the dumping of the sludge."

Plans for Dock at Keadby.

The Trent Navigation Company are contemplating the construction of a dock at Keadby, to take cargoes of merchandise from foreign steamers of larger size than those at present visiting the River Trent.

Harbour Entrance Improvement at Odense.

A scheme is being considered for the improvement of the entrance to the Port of Odense, Denmark. The plan includes the illumination of the channel, so as to avoid delay to vessels entering the port at night, and the cost of the entire project is expected to be about 135,000 kr.

Genoa Free Port.

A decree has been published by the Italian Government regarding the creation of a free port of Genoa, which will be operated by the Consorzio Autonomo del Ports in the same way as the Azienda dei Magazzini Generali operates the Port of Trieste. The new free port is to be put into commission as soon as the necessary works have been completed.

A New Canal in Roumania.

The Roumanian Government has decided to build a canal from Cernavoda to Costanza. The project, which is expected to cost over 4,000,000,000 lei, will take about five years to complete, and it is hoped work will be started in the spring of 1939. The canal will shorten the journey from the Danube to the Black Sea by about 155 miles.

Bucket Hopper Dredger for Ayr Harbour.

Early in March, Messrs. Wm. Simons & Co., Ltd., Renfrew, Scotland, launched the bucket hopper dredger "Carrick," which they have constructed to the order of the London, Midland & Scottish Railway Company for work at Ayr Harbour. The vessel is well equipped for dealing with all classes of material, and is designed for loading barges moored alongside as well as discharging into its own hopper, and of dredging to a depth of 32-ft. below water level.

Improvements at Barrow Docks.

In connection with improvements now being carried out at Barrow Docks, the London, Midland and Scottish Railway announces the placing of a contract for two pairs of new dock gates with Vickers-Armstrong, Limited. The gates are for the Ramsden Dock entrance and the entrance to the lock. The area at present covered by Buccleuch Dock is also being extended, and when completed, will facilitate the handling of hulls and completed vessels up to 800-ft. in length. During the past year nearly 600,000 tons of goods were handled at Barrow Docks, this being the highest total recorded since the War.

Port of Trieste.

The Chairman of the Azienda dei Magazzini Generali del porto di Trieste, has issued a review of the Port of Trieste during 1937, referring especially to the increase of the Central European and Danube transit trade through the port, and pointing out that Trieste has been able to recover only a portion of what it lost during the sanctions period. A wish was expressed for the conclusion of an Italo-German agreement in connection with the distribution of Central European and Danube transit trade between Adriatic and North Sea Ports. In regard to the development of trade through the Port of Trieste, the following figures showing imports and exports together in the course of the past few years are of interest: 1937—3,170,000 tons; 1936—2,185,867 tons; 1935—2,445,291 tons; 1934—2,406,966 tons.

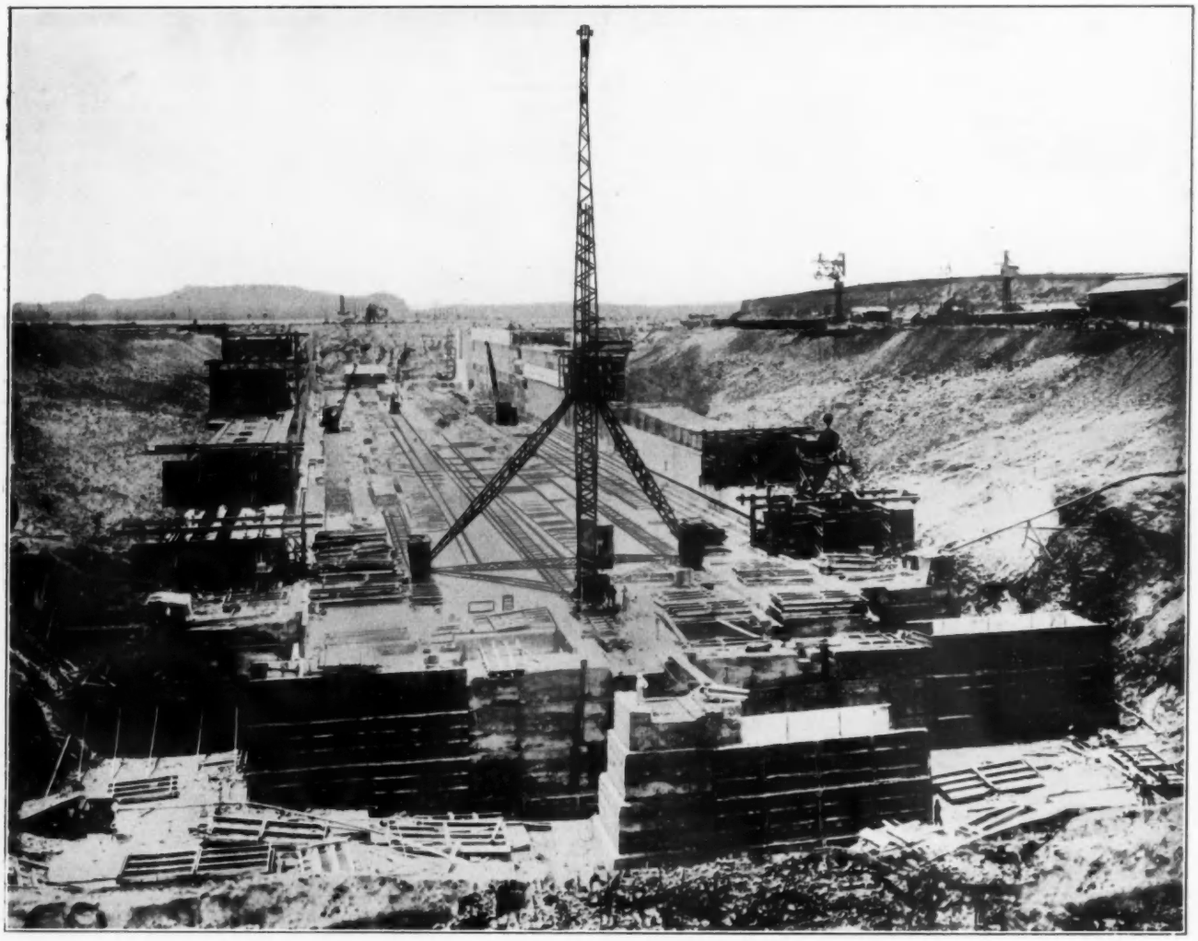
Proposed Airport near Tilbury.

There has been laid before the Air Ministry, the City of London Corporation, and the Port of London Authority, a proposal that a section of the River Thames at Lower Hope Reach shall be used as a seaplane base, and the adjoining land on the Essex side of the river, north-east of Tilbury, utilised as a site for an aerodrome. The area of water available for seaplanes will permit runways, 1½ miles in length, in all the necessary directions, and will afford the largest alighting area of any scheme yet proposed for a combined sea and land air base. The proposal also includes the provision of a tidal dock for the inspection and repair of flying-boats, with four bays giving access on the landward side to the airport building and stores. The aerodrome would be built on part of the 300 acres of land, which at present is being reclaimed. The site is about 26 miles from the centre of London, and is clear of obstructions. The latest scheme has the advantage of combining a land and sea air-base, which would be much nearer London than the alternative bases at either Portsmouth or Southampton.

The Singapore Naval Base

A Great Imperial Undertaking

(CONTRIBUTED)



Constructional Operations in progress at Graving Dock (May, 1932).

The Site and Preliminary Measures

SINGAPORE Naval Base lies on the North side of the Island of Singapore, being to the East of the Johore Causeway, which, completed of recent years, connects the island by road and rail with the mainland. In area the base covers nearly 2,400 acres, that is, about 4 sq. miles, and it has a water frontage to the Straits of Johore of about 4½ miles in length.

When preliminary work was commenced in 1923, this area consisted of rubber plantations interspersed with jungle and swamp. The necessary land for the Naval Base was acquired by the Government of the Straits Settlements, and presented to the Imperial Government. After a short abandonment, preliminary work was recommenced in 1925, and took the form of clearing of rubber and jungle, surveying, sinking trial pits and driving boreholes into the earth in order that the design of the various works might proceed and be planned to the best advantage.

The Base was designed by the Department of the Civil Engineer-in-Chief at the Admiralty, and a contract for the major civil engineering portion of the work necessary to form the dockyard was commenced by Sir John Jackson and Co., Ltd., in 1928, and completed in 1936. The Civil Engineer-in-Chief at the Admiralty, at the time when the design and contract particulars were prepared for the work, was Sir Leopold Savile, K.C.B., M.Inst.C.E., who was accordingly responsible for the design of the wharf walls and the graving dock, etc.

Constructional Operations

The constructional works were commenced under his direction and completed under his successors, Mr. T. B. Hunter, C.B., O.B.E., M.Inst.C.E., and Mr. A. L. Anderson, C.B., M.Inst.C.E.

This contract included the construction of the Dry Dock (which is 1,000-ft. long, 130-ft. wide at the entrance, and has a depth of water of 35-ft. at low tide), together with the formation of wharf walls, 2,200-ft. in length, having 40-ft. of water alongside at low water, and 2,970-ft. having 30-ft. of water. Part of this latter is in the form of a Tidal Basin, alongside which are large transit sheds for the purpose of handling the various Naval stores, and nearby which will shortly be erected commodious storehouses.

The Caisson at the dock entrance was constructed by Messrs. Sir Wm. Arrol and Co., Ltd., and the dock pumping machinery by Messrs. Gwynnes Pumps, Ltd.

Included in the contract were the levelling and preparation of the dockyard area, together with the driving of piled foundations for many of the workshops, which are now in course of erection.

Quantities of Work Executed

A few figures will be of interest in giving some idea of the magnitude of this contract.

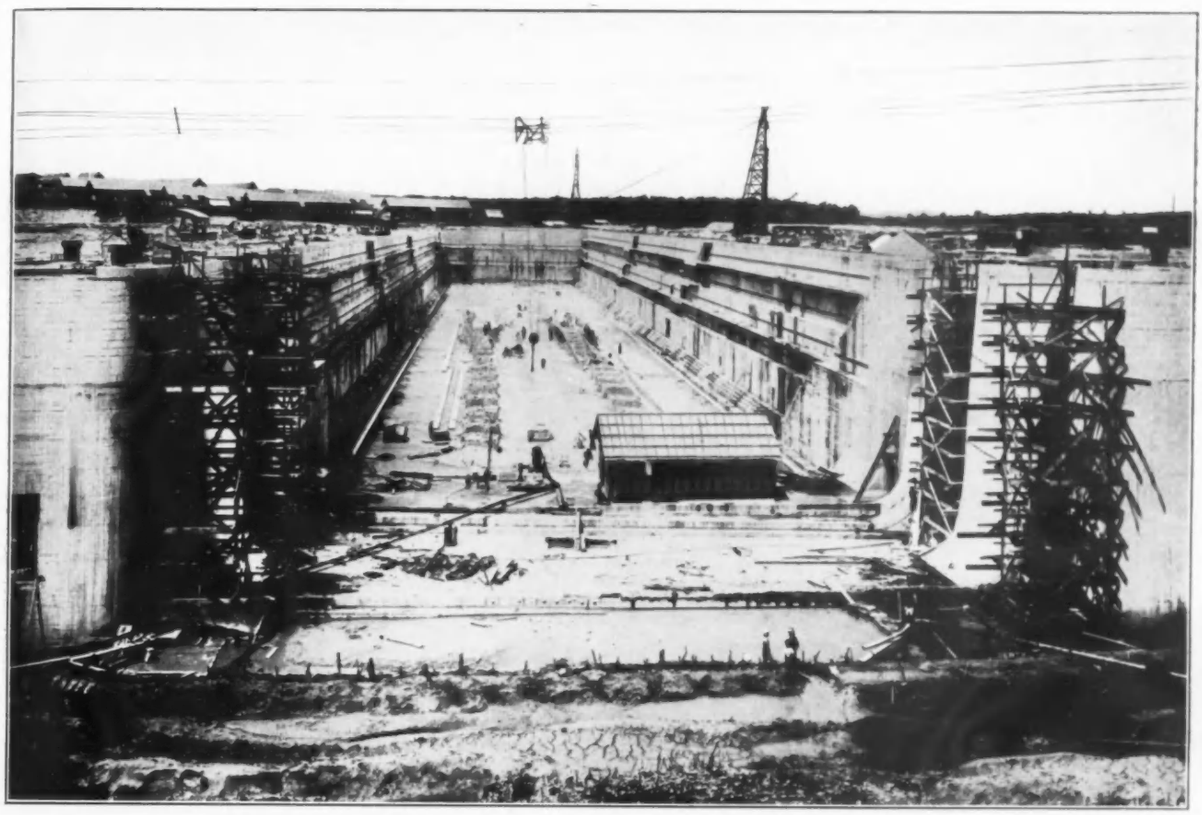
The preparation of the site involved the removal of about 8 million cu. yds. of earth, of which, of course, a large quantity came from the excavations for the dock and wharf walls. This material was used to reclaim swamp areas required in connection with other parts of the Naval Base and, in all, some 450 acres of swamp were thus converted into useable ground, on which to-day buildings are being erected.

To enable the wharf walls to be used, about 5 million cu. yds. of material was dredged and taken to sea. These walls and the dock consumed between them over 1 million cu. yds. of concrete and about a quarter of a million cu. ft. of granite blocks.

The granite for this concrete and for most of the blockwork was obtained from a hillside in the State of Johore, and from there was transported by temporary railway tracks through 4 miles of jungle to the Straits, across which it was conveyed in train ferries, each of about 100 tons capacity. The granite for the Caisson and Penstock faces in the dock was obtained from Cornwall.

To carry out the contract, the contractor had to lay about 16 miles of temporary railway track, and employed 4,000 to

Singapore Naval Base- continued



View of Graving Dock in September, 1934, nearing completion.

5,000 coolies, practically all of whom were housed in lines on the Base.

The work also involved the diversion of a river, the winding mouth of which was diverted by means of a new channel to join that of another river about a mile away.

The primitive communications within the area which existed before work was commenced have now been transformed beyond recognition. A wide motor roadway, with railway alongside, now runs from one end of the base to the other, and on a hill to the south of this road stands a large concrete reservoir, holding nearly 6 million gallons of water, fed from the main Singapore supply. The railway is connected to the Federated Malay States system, and the road unites the two public roads to east and west.

Within the Base itself, roads and railways have been constructed, and work is proceeding rapidly on the erection of the various workshops, offices, etc., requisite for a dockyard.

The Base is in itself a miniature self-contained township. Electrical energy for lighting and power is produced there, and it contains hospital and medical facilities for its resident population, who are being housed under suitable conditions, the Asiatic workpeople in permanently constructed lines and the European personnel in residences suited to the climate.

The provision of these residential facilities was necessitated by the geographical position of the Base, it being 15 miles by road from Singapore Town.

Large barrack buildings are also being erected to house the crews of Naval vessels, whilst in dock refitting, thus enabling them to escape the trying conditions to health which would result from remaining on board during these periods, and near-by these shore buildings are ample recreational facilities, such as football and cricket grounds and tennis courts.

So far, the estimated cost of completing the Civil Engineering and Building Works of the Naval Base is £9,735,000, of which about 6 millions has already been spent. Towards this cost, large contributions have been made by New Zealand, Hong Kong, and the Federated Malay States.

Singapore Harbour Board

Excerpts from the Annual Report for the Year ended 30th June, 1937

After providing for Interest and Sinking Fund Contributions in the sum of $2,552,737.54 and crediting $100,000.00 in respect of refund by Government of excess interest paid, and $250,000.00 advances in respect of Sinking Fund Relief, the Income and Expenditure Account shows a surplus of $479,479.92 as compared with a surplus of $544,348.25 last year.

Of the total expenditure for the year as shown in the Income and Expenditure Account, amounting to $7,081,870.97 the amount of $2,814,340.28 or 25%, is uncontrollable by the Board, being Interest and Sinking Fund Contributions, Municipal Assessment and Audit Fees.

The number and total net registered tonnage of vessels berthed at the wharves was 3,242 vessels and 9,708,417 tons, an increase of 111 vessels and 71,619 tons, compared with 1936.

The trade handled at the wharves during the year was, in the aggregate 3,141,436 tons or 19% more than that for the previous year. General cargo inward increased by 286,991 tons or 27%, whilst general cargo outward increased by 108,282 tons or 11%. Coal inward increased by 44,133 tons or 23%, whilst coal outward increased by 43,192 tons or 22%. Fuel oil inward increased by 11,543 tons or 13%, and fuel oil outward increased by 13,991 tons or 18%.

The average percentage of quayage occupied during the year was 66% as compared with 65% for the previous year, and the average length of quayage occupied per vessel was 408-ft. as against 410-ft.

The necessary legislation governing the conveyance, loading and unloading of dangerous goods carried in vessels berthed at the Board's wharves (the Ports (Amendment) Ordnance 1936) was passed during the year and the new by-laws, having been submitted to the Mercantile Marine Department of the Board of Trade, were duly approved by the Governor in Council and came into force on the 1st April, 1937.

With reference to the tenders called for by the Board for the installation of mechanical plant for discharging coal at the new wharves in course of construction, the work of the erection of the plant has been commenced since the close of the financial year. The Board, after discussions with coal importers and shipowners, decided to purchase mechanical plant for bunkering vessels, and have placed an order for one land mechanical coal bunkering plant and one floating mechanical bunkering plant to work in conjunction with the coal discharging plant.

Plans for the reconstruction of the East Wharf have been prepared and the work will be undertaken as soon as practicable. Substantial progress continued to be made with the construction of the West Wharf Extension, and during the year under review the Board took over and put into use some 1,160 lineal feet of the new wharves.

*An Experimental Investigation of the Effect of Bridge-Piers and other Obstructions on the Tidal Levels in an Estuary**

By Professor ARNOLD HARTLEY GIBSON, D.Sc., LL.D., M.Inst.C.E.

INTRODUCTION.

ANY proposal to erect bridge-piers, or works in any way restricting the waterway of a tidal estuary, is usually opposed by port authorities interested in the navigation of the estuary, not only on the grounds that such obstructions will increase the difficulties of navigation, but also because they will affect the flow of water into and out of the upper estuary. It has been generally considered that any constriction in the waterway must reduce the volume of water entering and leaving the upper estuary, and all authorities are agreed that any very appreciable reduction in the volume of flow would be likely to affect adversely the navigable channels up- and downstream. In the past no data have been available as to the probable magnitude of the effect of such obstructions in any particular case, and in view of proposals in recent years to build bridges across certain estuaries in Great Britain, the Author thought it might be of interest to attempt to measure the effect of obstructions of different magnitudes in a model of one of the estuaries concerned.

PREVIOUS TESTS.

Experiments on a Model of the Severn Estuary.

Some few years ago a model of the Severn estuary, to a horizontal scale of 1 : 8,500 and a vertical scale of 1 : 200, was constructed and operated for the Severn Barrage Committee in the engineering laboratory of Manchester University. In the course of the experiments the effect of various designs of barrage was investigated. These were founded on the English Stones, a rock plateau about 5 miles upstream from Avonmouth. In each design water, on the flood tide, passes into the estuary between a series of sluice-gate piers, and afterwards passes between the piers of a rail-and-road viaduct. The obstruction of the waterway at high water varied in the different schemes from 63·6 per cent. of the cross section as a minimum to 82·8 per cent. as a maximum.

The effect of these obstructions on the level of high-water spring tides in the upper estuary at Beachley, immediately above the barrage, and at the upper extremity of the estuary, at Gloucester, was observed in the course of the investigation. After making slight adjustments for the differences of low water in the tidal basin in the different experiments, the figures are as follows :—

Obstruction : per cent. of cross section of waterway.	Lowering of high-water spring-tide level : inches.	
	Beachley.	Gloucester.
63·6	8·4	16·0
66·8	10·8	22·8
74·6	14·4	33·6
82·8	31·0	44·4

On plotting these figures on a base representing the percentage obstruction of waterway, it appears that the effect falls off very rapidly as the obstruction is diminished ; owing, however, to the fact that the smallest of these obstructions is so large, the extrapolation of this curve to give values for small obstructions is too speculative.

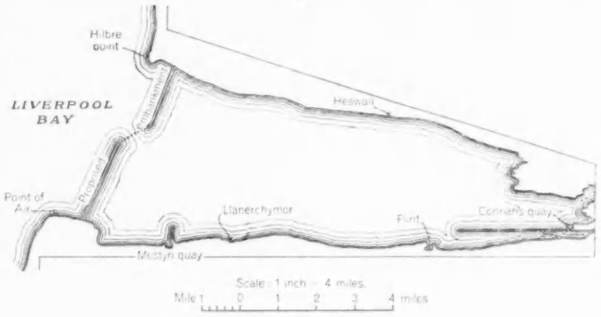
Experiments on a Model of the Dee Estuary.

In 1931 a model incorporating the estuaries of the Dee and Mersey and a considerable area of Liverpool Bay was constructed, and was operated in the engineering laboratory of Manchester University. This had a horizontal-scale ratio of 1 : 7,040, and a vertical-scale ratio of 1 : 192.

In the course of the investigation, the effect of a suggested embankment and bridge across the mouth of the estuary of the Dee between Point of Air and Hilbre Point was examined. The line of the proposed work is shown in *Fig. 1* (p. 212). It was to consist of two solid embankments connected by a central bridge having thirteen spans, with piers each 28 feet wide at 320-foot centres. The width of the estuary at this site is 5·25 miles and the area of the cross section at high-water spring tide is approximately 950,000 square feet. The width of the waterway between the proposed piers is 3,940 feet, and the obstruction of the cross-sectional area of the estuary at high water caused by the work is 74 per cent.

Tide-curves were taken in the model at points corresponding to Llanerchymor, Heswall, Pentre, and Connah's Quay, before and after the introduction of the bridge and embankment, the tidal range at spring tides in each case being 31·9 feet at Liverpool. The curves taken immediately after the introduction of the obstruction, before any substantial change had taken place in the channels of the upper estuary, showed that the mean level of high water had been lowered by 1·2 foot and the mean level of low water had been raised 0·6 foot.

Fig. 1.



ESTUARY OF RIVER DEE.

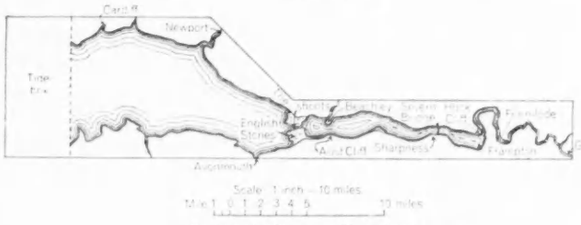
This lowering of the mean high-water level compares with the figure of approximately 2·0 feet in the Severn with the same percentage obstruction. Since the spring-tide range at the obstruction is 29 feet in the Dee and 41 feet in the Severn, the ratio of the changes in high-water level is of the same order as that of the tidal ranges. As the new configuration of the estuary developed under the influence of the altered conditions, the level of high water gradually increased, until after a time corresponding to 40 years of tides, when the estuary had become stabilized, the mean level of high water was 0·4 foot higher than before the introduction of the obstruction, while the level of low water was 0·3 foot higher. Under these conditions the scour at the bridge had increased the area of waterway until the percentage obstruction at H.W. amounted to approximately 66 per cent. of the cross section of the original waterway.

Observation showed that the time of high water at spring tide in the estuary is later with the embankment in existence, there being a delay of 37 minutes at Heswall, 59 minutes at Pentre, and 67 minutes at Connah's Quay. At neap tides observation showed that the mean high-water level was 0·2 foot higher with than without the embankment, while the low-water level was not appreciably altered. At the time these latter results were looked upon as being somewhat anomalous, but as it became necessary to remove the model, the matter was not pursued further.

EXPERIMENTS ON A SMALL MODEL OF THE SEVERN ESTUARY.

When, recently, the present investigation was begun, neither the Dee model nor the original large model of the Severn was available, the latter having been dismantled some years previously. A very small model of the Severn, which had been constructed with a view to demonstrating the general working of such models rather than for experimental work, was, however, available, and it was decided to explore its possibilities. The model is shown in *Fig. 2*, and includes the estuary from Gloucester to a point 14 miles seaward of Avonmouth. The horizontal-scale ratio is 1 : 40,000, the vertical-scale ratio is 1 : 366, and the time-scale ratio is 1 : 2,090. The overall length of the model is 6 feet.

Fig. 2.



SCOPE OF SEVERN TIDAL MODEL.

The method of visual observation of the water-levels against graduated tide-gauges, which had been used to obtain tidal data in the larger model with its larger and slower tides, was useless for the purpose of obtaining sufficiently accurate measurements, but it was found that by using a micrometer depth-gauge with a needle-point extension, and by observing through a magnifying lens, changes in the level of high water amounting to 0·001 inch, corresponding to 0·4 inch in nature, could readily be measured, while changes of one-half of this magnitude could be detected.

In order to check the accuracy of the model in reproducing the tidal phenomena in the open estuary, observations of the levels of high water and of the tidal range at spring tides were made at a series of points. The range of normal spring tides at Avonmouth is 40·4 feet, corresponding to 1·33 inch in the model. The mechanism was set to give the correct high-water level and range at Avonmouth, and the values obtained after some adjustments are shown in the following Table, together with the corresponding figures for the estuary

* A Paper read before the Institution of Civil Engineers, February 8th, 1938. Note: The page numbers appearing in the article refer to the March 1938 issue of the Journal of The Institution of Civil Engineers.

given by the Admiralty and appearing in the Appendix to the Report of the Sub-Committee of the Severn Barrage Committee.[1]

		Avonmouth.	Beachley.	Severn Bridge.	Framilode.	Gloucester.
Level of high-water spring tides: feet above O.D.	Model	22·5	23·2	25·4	26·9	26·1
	Estuary	22·5	23·4	25·5	27·0	26·0
Range: feet . .	Model	40·4	41·4	28·8	11·3	6·6
	Estuary	40·4	41·0	28·9	11·5	6·5

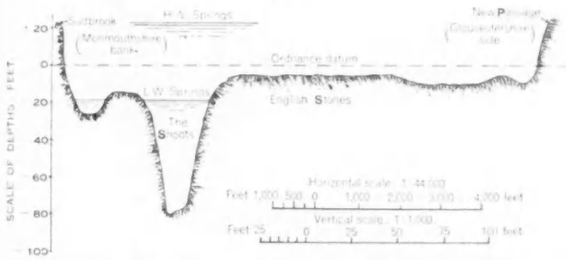
As a further check on the accuracy of the model, a series of float observations was made, in which floats were released at the seaward end of the Shoots at the beginning of a spring flood tide. Observations by the Admiralty, recorded in the Report of the Severn Barrage Committee, show that such floats travelled upstream to Framilode, a distance of some 33 miles, the time being 5 hours 52 minutes. In the model the floats travelled to within $\frac{1}{2}$ inch of the corresponding point and the mean time was 10·0 seconds, corresponding to 5 hours 48 minutes in nature. Further observations showed that a float released at Framilode at high-water spring tides travels downstream to Severn Bridge in 6·60 seconds, corresponding to 3 hours 50 minutes in nature. Corresponding Admiralty observations in the estuary gave a time of 3 hours 54 minutes.

The general effect on the tidal phenomena of the natural obstructions and resistances in the estuary is so closely reproduced in the model as to justify the conclusion that the effect of any added artificial obstruction and resistance will be equally well reproduced.

Following this calibration of the model a series of obstructions, of the nature of bridge-piers, was placed across the English Stones, in a line parallel to and about 500 feet seaward of the line of the Severn tunnel. This is the site originally chosen for the suggested Severn bridge. Here the tidal range at springs is approximately 41 feet, high-water level being +22·5 O.D. The average level of the English Stones at the site is −7·5 O.D. The cross section is approximately as shown in *Fig. 3*. The Stones are uncovered for about 2 hours on either side of low-water springs, and the last of the ebb discharge takes place through the narrow rock gorge called the Shoots. The cross-sectional area at high water is some 460,000 square feet, and the area of the estuary at high water, above the line of the proposed bridge, is 34·8 square miles.

The obstruction offered by the piers of the proposed bridge was 8 per cent. of the cross section at high water, but experiments were carried out in the model with obstructions ranging up to 60 per cent. of the cross section. The smaller obstructions—those up to 20 per

Fig. 3.



CROSS SECTION OF RIVER SEVERN AT THE ENGLISH STONES SITE.

cent.—consisted of a series of equally-spaced bridge-piers of elliptical section, with the longer axis approximately 3 times the shorter. The larger obstructions were pier-shaped masses placed on the English Stones in the line of the proposed bridge.

In each case measurements were made of the levels of high and low water at Avonmouth, Beachley, off Frampton, and at Gloucester, and of the times of high water at Avonmouth, Beachley and Gloucester, with and without the obstruction in position.

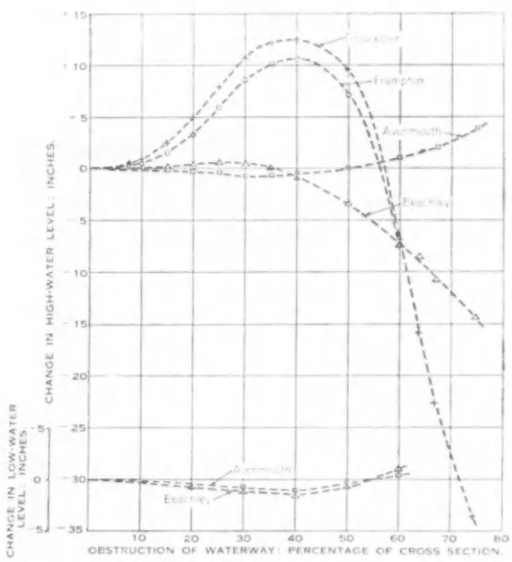
The main results of the observations are shown in the Table on p. 216 and in *Fig. 4* (p. 216), which also shows the results of the tests on the Severn Barrage model.

In this Table, positive values represent an increase in the level of high water.

The experiments showed the unexpected result that for obstructions of less than 35 per cent. the level of high water everywhere upstream is higher with than without the obstruction. The effect is greatest at the upper end of the estuary, where it is a maximum (12·4 inches) with a 40-per-cent. obstruction. The downstream high-water level at Avonmouth is only very slightly changed with obstructions less than 50 per cent., and is increased with greater obstructions. The effect on the level of low water is very small. At Avonmouth it is lowered slightly with obstructions of up to 50 per cent., while at Beachley, above the obstruction, it is lowered slightly with small obstructions, and higher up the estuary at Frampton and Gloucester the effect is negligible.

Obstruction of waterway: percentage of cross section.	Effect on level of high-water spring tides: inches in nature.				Delay in time of high-water slack: minutes in nature.		
	Avonmouth.	Beachley.	Frampton.	Gloucester.	Avonmouth.	Beachley.	Gloucester.
7·5	Small.	Small.	+0·4	+0·6	0·4	1·6	1·0
10·0	Small.	Small.	+0·6	+0·9	0·6	2·0	1·2
15·0	−0·3	+0·2	+1·5	+2·5	1·1	3·3	2·0
20·0	−0·5	+0·3	+3·3	+5·0	2·0	5·5	2·9
25·0	−0·6	+0·6	+6·0	+7·8	3·0	8·3	4·2
30·0	−0·7	+0·5	+8·5	+10·6	4·0	12·0	6·2
35·0	−0·6	0·0	+10·1	+12·2	6·0	17·3	8·4
40·0	−0·5	−1·0	+10·5	+12·4	8·0	23·4	11·2
50·0	0·0	−3·5	+7·0	+9·5	14·5	40·0	18·3
60·0	−1·0	−7·5	−7·5	−7·0	20·6	59·0	28·1

Fig. 4.



EFFECT OF OBSTRUCTIONS AT THE ENGLISH STONES ON THE LEVELS OF HIGH- AND LOW-WATER SPRING TIDES.

In view of the nature of the results it was decided to repeat the experiments with piers at another section of the estuary, and these were installed along a line between Beachley and Aust Cliff. At this site, which is about 2½ miles above the English Stones, the width of the channel is reduced to 1 mile. The area of the waterway at high water is about 230,000 square feet. The area of the upstream estuary is 28·3 square miles at high water and the volume passing at spring tides is some 18,500 million cubic feet, or 75 per cent. of that passing the English Stones, so that mean velocities are some 50 per cent. greater than at the latter site. The Beachley site differs from the English Stones in that as the piers are founded in the bed of the channel their effect is felt down to low water. Also, whereas at the Stones the piers rest on a rock plateau, so that the question of erosion of the bottom or movement of sandbanks in the vicinity does not arise, there are sandbanks at the Beachley site. To prevent complications due to any erosion of the bed altering the cross-sectional area, it was stabilized for the purpose of these experiments by a light wash of weak cement.

The results of these tests are given in the Table on p. 218 and in *Fig. 5*, p. 219.

The general results are of the same kind as in the previous experiments. The maximum effect, at Gloucester and Frampton, is somewhat greater and is attained with a greater obstruction—about 50 per cent. With this the high-water level is raised 14·6 inches at Gloucester, 12·0 inches at Frampton, and 1·5 inch at Beachley. Low-water level at Beachley is raised 3·0 inches, at Avonmouth it is lowered 0·6 inch, while at Frampton and Gloucester it is not appreciably altered.

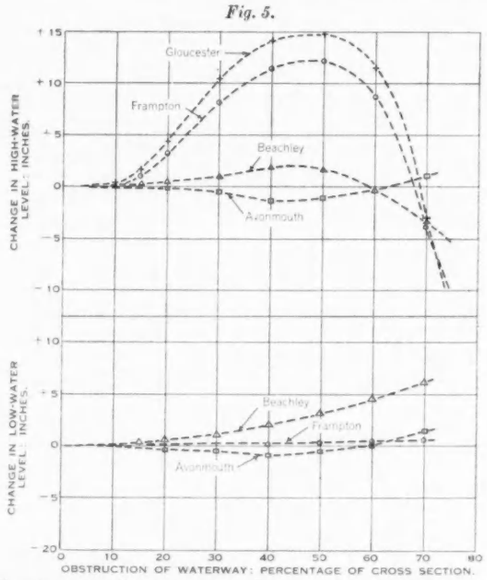
It was next decided to attempt to obtain tide-curves for the estuary, both without any obstruction and with this 50-per-cent. obstruction. No difficulty was experienced in obtaining a series of points on the flood-tide curve. The needle of the micrometer having been adjusted to some predetermined level between high and low water, the instant at which the rising tide reached this was recorded by chronometer, the datum time being fixed by the instant at which a point on the driving disc of the tidal mechanism passed a given mark. The mean of a series of four observations at each height was found to

[1] Published by H.M. Stationery Office. Publication No. 63–78–1, p. 21. 1933.

Obstruction of waterway: percentage of cross section.		7·5	10	15	20	30	40	50	60	70
Effect on level of high-water springs: inches.	Avonmouth	†—v.s.	—v.s.	—v.s.	—0·2	—0·6	—1·5	—1·2	—0·4	+1·0
	*Beachley	+v.s.	+v.s.	+0·2	+0·4	+1·0	+1·8	+1·5	—0·4	—3·5
	Frampton	+v.s.	+0·2	+1·0	+3·2	+8·0	+11·3	+12·0	+8·6	—4·0
	Gloucester	+v.s.	+0·3	+1·6	+4·4	+10·4	+14·1	+14·6	+11·5	—3·0
Effect on level of low-water springs: inches.	Avonmouth	—v.s.	—v.s.	—v.s.	—0·4	—0·6	—1·0	—0·6	0·0	+1·3
	*Beachley	v.s.	v.s.	+0·3	+0·5	+1·0	+2·0	+3·1	+4·5	+6·2
	Frampton					very small			+0·4	+0·5
	Gloucester					very small				
Delay in time of high-water slack: minutes.	Avonmouth	v.s.	0·4	1·0	2·0	4·0	6·5	9·5	14·4	20·0
	*Beachley	0·9	1·2	3·0	4·8	11·2	21·0	35·0	51·5	70·0
	Frampton	v.s.	0·9	2·0	3·9	8·6	15·1	25·0	36·0	48·5
	Gloucester	v.s.	0·6	1·2	2·4	5·6	10·8	17·5	26·0	35·5
Delay in time of low-water slack: minutes.	Avonmouth	v.s.	0·4	1·1	1·5	2·6	4·1	6·0	8·4	10·8
	*Beachley	0·9	1·2	2·0	3·0	5·5	8·6	12·5	18·0	21·6
	Frampton	v.s.	0·9	1·3	2·2	3·8	6·0	9·4	13·0	16·6
	Gloucester	v.s.	0·6	1·2	1·9	3·1	5·0	8·0	11·1	14·8

* The Beachley figures refer to a point 400 yards above the obstruction. † "v.s." signifies "very small."

Fig. 5.



EFFECT OF AN OBSTRUCTION AT BEACHLEY ON THE LEVELS OF HIGH- AND LOW-WATER SPRING TIDES.

give a value which could be repeated without difficulty. More difficulty was experienced on the ebb tide owing to the formation of a meniscus which clung to the gauge-point. The method finally adopted was to observe the times at which the meniscus broke away from the point. Observation showed that when the point was raised from below the surface of still water the meniscus broke away when the point was 0·025 inch above the level of the surface, and in plotting the tide-curves each observed level on the ebb has been lowered by this amount. This correction renders the ebb-curves less reliable than the flood-curves. Any error involved will, however, be sensibly the same for corresponding observations with and without the obstruction in position, and the relative values should not be affected.

In the experiments tide-curves were obtained at Avonmouth, Beachley (about ¼ mile above and below the obstruction), Sharpness, and Gloucester. These are shown in *Figs. 6* (pp. 220–1), on a scale representing corresponding tidal levels and times in the actual estuary. At Avonmouth the two curves are almost identical. Below Beachley the effect of the obstruction is mainly felt on the flood tide, which rises relatively more quickly when the estuary is obstructed. Above Beachley and at Sharpness the effect is much greater, and there is a definite lag which becomes most pronounced during the latter half of the flood tide.

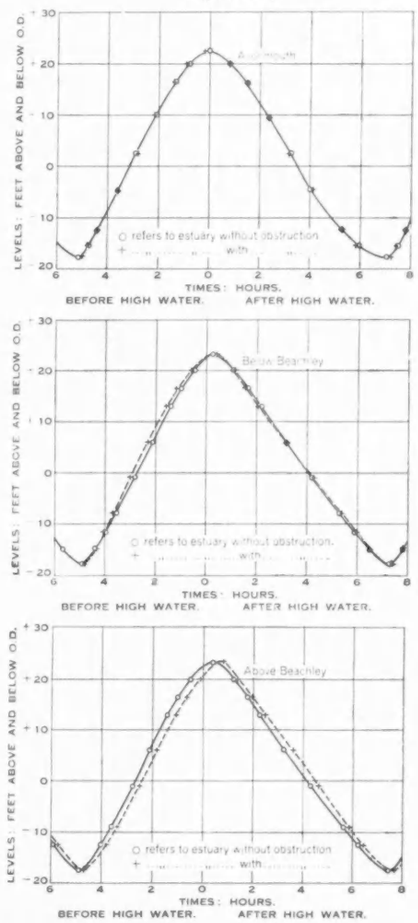
At first sight the fact that the introduction of an obstruction, with the additional resistance which it causes, is accompanied by an increase in the tidal range and in the volume of water entering the upper estuary would appear to involve a violation of laws of the conservation of energy. An analysis of the tide-curves, however, shows that this is not the case. If the surface-levels at any tide-gauge station are measured at equal intervals of time, and if the heights above low-water level are measured at the middle of each interval, the sum of the products of the height and the rise in level during any interval is a measure of the potential energy per unit of surface-area at that station. The sum of such products from low water to high water is a measure of the energy of the flood tide, and that from high water to low water is a measure of the energy of the ebb tide.

If the tide-curves obtained with and without the 50-per-cent. obstruction at Beachley are analysed in this way, the following results are obtained :—

Site.	Potential energy per square foot of surface-area: ft.-lb.			
	Flood tide.		Ebb tide.	
	Normal.	With 50-per-cent. obstruction.	Normal.	With 50-per-cent. obstruction.
Avonmouth	55,600	55,600	53,300	53,300
Below Beachley	55,400	55,000	54,000	53,500
Above Beachley	54,500	52,000	53,200	51,700
Sharpness	30,300	29,500	27,400	26,900

The figures give the energy in foot-lb. per square foot of surface-area in the estuary at the section in question. Taking the flood-tide observations as being the more reliable, they show that the tidal energy of a flood tide in the upper estuary is reduced by about 4 per cent. by the introduction of the obstruction, the effect being less at Sharpness than lower down the estuary at Beachley.

Figs. 6. (a)

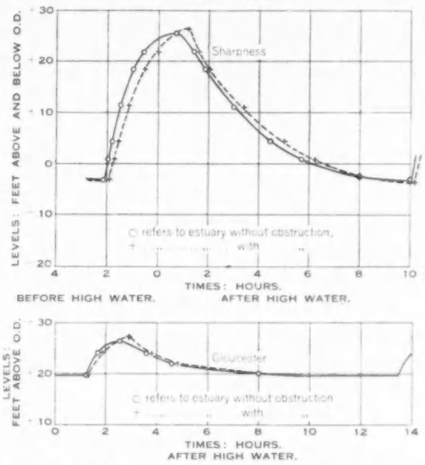


TIDE-CURVES WITH AND WITHOUT A 50-PER-CENT. OBSTRUCTION AT BEACHLEY.

TESTS ON A MODEL OF A SYMMETRICAL TIDAL ESTUARY.

It was next decided to carry out similar tests on another form of estuary in order to ascertain whether or not the phenomenon just described is due to the peculiar conformation of the Severn estuary, and a model was constructed of a symmetrical tidal estuary of the

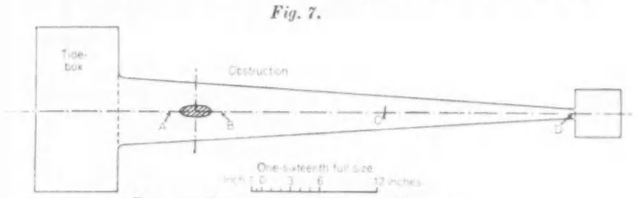
Figs. 6. (b)


LEVELS: FEET ABOVE AND BELOW O.D.
Sharpness
○ refers to estuary without obstruction,
+ ... ... with ...
TIMES: HOURS.
BEFORE HIGH WATER. AFTER HIGH WATER.
LEVELS: FEET ABOVE O.D.
Gloucester
○ refers to estuary without obstruction
+ ... ... with ...
TIMES: HOURS.
AFTER HIGH WATER.

TIDE-CURVES WITH AND WITHOUT A 50-PER-CENT. OBSTRUCTION AT BEACHLEY.

dimensions and proportions shown in *Fig. 7*. This was made of galvanized iron with a smooth and level bed. A series of obstructions was placed at a point 40 inches from the top of the estuary, where the

Fig. 7.



PLAN OF SYMMETRICAL-ESTUARY MODEL.

width is 6 inches. The effect on the level of high water at the top of the estuary is as follows :—

Obstruction of waterway : percentage of cross section.	20	30	40	50	60	70	80
Change in level at top of estuary (actual) : inch . .	+0·0025	+0·0050	+0·0105	+0·0210	+0·0340	+0·0260	+0·0040

Assuming this to represent an estuary to the same scales as the Severn model, the maximum effect on the high-water level is equivalent to an increase of 12·4 inches. This maximum effect is obtained with a 60-per-cent. obstruction. Tide-curves were taken with and without this obstruction in place at the following points (*Fig. 7*) : below the obstruction (A) ; at the upper end of the estuary (D) ; and half-way between the obstruction and the upper end (C). These tide-curves are shown in *Figs. 8*, p. 224.

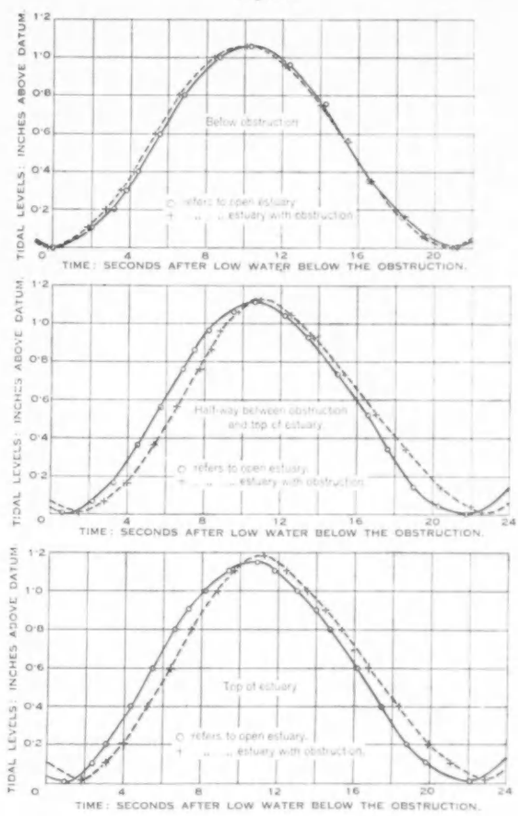
The observations show the following results :—

Site.	Range of tide : inch.		Relative levels with 60-per-cent. obstruction.	
	Without obstruction.	With obstruction.	High water.	Low water.
Seaward end of estuary .	0·976	0·976	0·00	0·00
Just below obstruction .	1·060	1·060	—0·003	—0·003
Just above obstruction .	1·070	1·069	0·0	+0·001
Half-way between obstruction and top of estuary	1·108	1·115	+0·012	+0·005
Top of estuary . . .	1·180	1·204	+0·034	+0·010

This model differs essentially from that of the Severn in having a level bed, with the result that the range of tide is greatest at the upper end of the estuary. The results of an obstruction are, however, of the same general kind. An analysis of the tide-curves gives the following results, the units being arbitrary :

Site.	Tidal energy per unit area.			
	Flood.		Ebb.	
	Without obstruction.	With obstruction.	Without obstruction.	With obstruction.
Below obstruction .	57·4	57·4	56·2	55·7
Just above obstruction	54·0	51·8	52·9	51·4
Half-way along tidal basin	65·1	64·0	62·5	62·0
At upper end . .	66·0	65·2	63·9	63·4

Figs. 8.


TIDAL LEVELS: INCHES ABOVE DATUM
Below obstruction
○ refers to open estuary
+ ... ... estuary with obstruction
TIME: SECONDS AFTER LOW WATER BELOW THE OBSTRUCTION.
Half-way between obstruction and top of estuary
Top of estuary

TIDE-CURVES FROM SYMMETRICAL-ESTUARY MODEL WITH AND WITHOUT A 60-PER-CENT. OBSTRUCTION.

In this case the mean energy of a flood tide is approximately 2·5 per cent. less with the obstruction than without it.

In these experiments the depth of water at high water was 2·35 inches at the seaward end and 2·47 inches at the top of the estuary. With the same depth of water, but with the bottom covered with a layer of sand of medium coarseness, the effect of the obstruction was greater, the level of high water at the top of the estuary being raised by the equivalent of 13·7 inches as compared with the equivalent rise of 12·4 inches with the smooth bottom.

With a sloping sandy bottom, and with the same depth of water at the seaward end and a depth of 1·5 inch at the top of the estuary, the same obstruction raised the level of high water at the top of the estuary by the equivalent of 14·6 inches. When the general level of the water was lowered 0·25 inch, the obstruction raised the level of high water by the equivalent of 16·4 inches.

FURTHER EXPERIMENTS ON THE SEVERN MODEL.

A further series of tests was next carried out on the Severn model with various modifications.

In the first of these, a 20-per-cent. obstruction was placed on the English Stones, together with a 30-per-cent. obstruction at the Beachley site. The effect of this combination was to increase the high-water level at Beachley by 1·3 inch, that at Frampton by 10·6 inches, and that at Gloucester by 14·5 inches. With the 30-per-cent. obstruction at Beachley alone, these figures were respectively 1·0 inch, 8·0 inches and 10·5 inches, while with the 20-per-cent. obstruction at the English Stones they were 0·5 inch, 3·4 inches and 5·0 inches, so that the effect of this particular combination was approximately equal to the sum of the effects of its components.

In a second experiment the estuary was blocked at Hock Cliff, cutting off the 20 miles of river channel between this point and Gloucester. With a 50-per-cent. obstruction at Beachley the high-water level just above Beachley was 4·4 inches higher than without the obstruction, while at Frampton the high-water level was raised 4·8 inches. These figures compare with 1·5 inch and 12·0 inches when the estuary is open to Gloucester.

The effect of removing the Beachley peninsula was tried in a third experiment. This increases the area of the waterway at Beachley by 60 per cent. As a result the level of high water was lowered at all points in the upper estuary, by 1·2 inch at Beachley, by 5·5 inches at Frampton, and by 6·6 inches at Gloucester, while the level of low water at Beachley was very slightly lowered. In this estuary (that is, without the Beachley peninsula), the maximum increase in the level of high water upstream, due to an obstruction at Beachley, is produced by an obstruction equivalent to the peninsula plus 50 per

cent. of the original waterway, which together are equivalent to 70 per cent. of the enlarged waterway. This obstruction raises the high-water level at Gloucester by 21·2 inches, that at Frampton by 17·5 inches, and that at Beachley by 2·8 inches.

In a fourth experiment, the estuary was restored to its normal condition, and the effect of reducing the area of the waterway at Sharpness was examined. Here all reductions of area amounting to less than 25 per cent. slightly increased the level of high water at Gloucester. With a 25-per-cent. obstruction the level was the same as without the obstruction. With a 50-per-cent. obstruction the high-water level at Gloucester was lowered by 1·5 inch.

In a fifth experiment, the speed of the tidal gearing was reduced so as to give a tidal period of 40·80 seconds instead of 21·15 seconds. This naturally changed the tidal characteristics and reduced the level of high water at all points above Avonmouth. Under these conditions a 50-per-cent. obstruction at Beachley raised the high-water level at Frampton by 2·9 inches and that at Gloucester by 3·8 inches. These figures compare with 12·0 inches and 14·6 inches with the normal tidal period. The squares of the tidal periods are in the ratio 3·7 to 1, so that the ratio of the effects is approximately the same as that of the inverse square of the periods and therefore of the velocities.

A similar experiment with a 40-per-cent. obstruction at the English Stones showed that this raised the high-water level at Frampton by 2·4 inches, as compared with a rise of 10·5 inches with the normal tidal period. Here again the ratio is approximately the same.

Discussion of Results.

The results observed in these various experiments would appear to be due to partial resonance.

The mass of water in the upper estuary forms a system which, if suddenly isolated, would surge to and fro until it attained its equilibrium level. The period of this surge is less than the tidal period. This is acted upon by a periodic force—the tidal impulse—whose magnitude varies with time, approximately according to a cosine law. The motion is opposed by various hydraulic resistances, and the resultant tidal phenomena in the upper estuary are largely governed by the interaction of these forces.

The question is too complex for mathematical analysis, but some light on the problem may be obtained by considering the analogy of a solid system capable of natural vibration, acted upon by a periodic force obeying a cosine law, and having its motion resisted by a frictional force. If this latter force is proportional to the velocity the problem is capable of mathematical solution.

The equation of motion becomes of the form

$$\frac{w}{g}\frac{d^2x}{dt^2} + \mu\frac{dx}{dt} + Sx = Q\cos\alpha t,$$

where w denotes the weight of the vibrating body,
g ,, acceleration due to gravity,
x ,, displacement of the vibrating body,
t ,, time,
μ ,, frictional coefficient,
S denotes the elastic restoring force when the displacement x is unity,
$2\pi/\alpha$,, period of the applied force,
and Q ,, maximum value of the applied force;

or

$$\frac{d^2x}{dt^2} + p\frac{dx}{dt} + f^2x = q\cos\alpha t,$$

where $2\pi/f$ denotes the period of the natural oscillation;
and q is a constant.

The ultimate displacement x from the equilibrium position a time t is then given by

$$x = \frac{q}{\sqrt{(f^2-\alpha^2)^2 + \alpha^2p^2}}\cdot\cos(\alpha t + \gamma),$$

where γ denotes $\tan^{-1}\dfrac{\alpha p}{f^2-\alpha^2}$, and is the difference of phase between the vibration of the body and that of the applied force.

The semi-amplitude of the resultant vibration is

$$\frac{q}{\sqrt{(f^2-\alpha^2)^2 + \alpha^2p^2}}.$$

With a given applied force, and with a system in which the natural period of vibration is independent of the frictional resistance, any increase in this resistance would reduce the amplitude, but if the increase in frictional resistance increased the time of natural vibration (that is to say, if it reduced f), the amplitude might be either increased or reduced, depending on the relative values of f, α, and p.

The state of affairs in the actual problem naturally differs in important respects from that of this elastic vibrating system. The natural vibration of the estuarine column does not consist of a simple single surge from end to end, but is very complex, and its period varies somewhat at different points in the estuary; nor is the lag, or difference of phase between the tidal oscillation in the upper estuary and that in the lower estuary, the same at all points, or indeed the same at high water as at low water.

Also, in the estuary and model the resistance is proportional to v^n, where n is approximately equal to 2, instead of being proportional to v. In such a case, however, experience on other problems involving surges (such as occur, for example, in the pipe-lines of hydraulic power-plants fitted with surge-tanks) shows that a close approximation to the actual results may be obtained by assuming that the resistance is proportional to v, and by adopting a value for the frictional coefficient which will make the calculated value of the mean friction over the given range of velocities equal to its true mean value.

Observation shows that the introduction of an obstruction in the upper estuary increases the period of the natural oscillation in this part of the estuary, although that in the open estuary below Avonmouth is almost unaltered. The following Table shows the period, in seconds, of this surge both in the normal estuary and with a 50-per-cent. obstruction at Beachley :—

Site.	Period of surge : seconds.	
	Normal estuary.	With 50-per-cent. obstruction.
At seaward end of model . . .	6·65	6·65
Avonmouth	6·58	6·60
English Stones	6·32	6·58
Beachley	6·20	6·48
Sharpness	6·12	6·40

The obstruction also causes a lag in the times of high and low water in the upper estuary, and thereby increases the difference of phase between the tidal oscillations above and below the obstruction.

Now, although the analogy with the simple vibrating system should not be carried too far, the simple analysis does enable some sort of calculation to be made of what might be expected to be the relative effect of obstructions of different amounts on the tidal amplitudes, in terms of the observed mean lags and periods, provided that the effect is due to resonance. Thus the curves of *Fig. 5* indicate that practically the same mean amplitude (tidal range) is obtained at points above Beachley with a 66-per-cent. obstruction at Beachley as when the estuary is open. Observation also shows that this obstruction causes a mean lag of 0·88 second in the time of the turn of the tide in the upper estuary, and since the time of a complete tide is 21·15 seconds the equivalent phase-lag is $\dfrac{0{\cdot}88\times360}{21{\cdot}15}$ degrees = 15 degrees greater when the obstacle is in position.

Observation also shows that the mean period of natural oscillation of the column in the upper estuary is 6·55 seconds when the obstruction is in position, and 6·16 seconds when it is removed. If the suffix o refers to the estuary without the obstruction,

then $\dfrac{2\pi}{f_o} = 6{\cdot}16$, $\dfrac{2\pi}{f} = 6{\cdot}55$, and $\dfrac{2\pi}{\alpha} = 21{\cdot}15$,

so that $f_o = 1{\cdot}02$, $f = 0{\cdot}96$, and $\alpha = 0{\cdot}297$.

Since the amplitude is the same in each case, and since the value of the applied force is the same in each,

$$(f^2-\alpha^2)^2 + \alpha^2p^2 = (f_o^2-\alpha^2)^2 + \alpha^2p_o^2.$$

Substituting the above values for f_o, f, and α gives

$$p^2 - p_o^2 = 2{\cdot}42.$$

But $p = \dfrac{f^2-\alpha^2}{\alpha}\cdot\tan\gamma$, and $p_o = \dfrac{f_o^2-\alpha^2}{\alpha}\cdot\tan\gamma_o$,

whence $$p^2 - p_o^2 = \left(\frac{f^2-\alpha^2}{\alpha}\right)^2\tan^2\gamma - \left(\frac{f_o^2-\alpha^2}{\alpha}\right)^2\tan^2\gamma_o,$$

which, on substituting the values of f_o, f, and α, gives

$$p^2 - p_o^2 = 7{\cdot}89\tan^2\gamma - 10{\cdot}30\tan^2\gamma_o.$$

But with a 66-per-cent. obstruction $\gamma - \gamma_o$ is 15 degrees and

$$p^2 - p_o^2 = 2{\cdot}42,$$

whence $2{\cdot}42 = 7{\cdot}89\tan^2(\gamma_o + 15 \text{ degrees}) - 10{\cdot}30\tan^2\gamma_o$.

The solution of this equation by trial and error gives $\gamma_o = 19$ degrees 30 minutes, so that $\gamma = 34$ degrees 30 minutes.

From this $$p = \frac{f^2-\alpha^2}{\alpha}\tan\gamma = 1{\cdot}93,$$

and $$p_o = \frac{f_o^2-\alpha^2}{\alpha}\tan\gamma_o = 1{\cdot}145;$$

p and p_o are measures of the resistance to flow with and without the obstruction in position. They indicate that this obstruction increases the overall resistance by 68 per cent.

Considering now the case of a 50-per-cent. obstruction, if it is assumed that the resistance due to this is less than that of the 66-per-cent. obstruction in the ratio of $\left(\frac{50}{66}\right)^2$, this makes the new value of

$$p - p_o = 0{\cdot}785 \times \left(\frac{50}{66}\right)^2 = 0{\cdot}451\ ;$$

but $$p_o = 1{\cdot}145$$

whence $$p = 1{\cdot}596.$$

Observation shows that $\gamma - \gamma_o$ now equals 9 degrees 15 minutes and therefore $\gamma = 28$ degrees 45 minutes, while the natural period is 6·44 seconds so that $f = \frac{2\pi}{6{\cdot}44} = 0{\cdot}976$, and f_o as before is 1·02.

$$\text{Then } \frac{\text{amplitude with obstruction}}{\text{amplitude without obstruction}} = \sqrt{\frac{(f_o{}^2 - \alpha^2)^2 + \alpha^2 p_o{}^2}{(f^2 - \alpha^2)^2 + \alpha^2 p^2}} = 1{\cdot}027.$$

A similar investigation for a 30-per-cent. obstruction, where $\gamma - \gamma_o = 3$ degrees 30 minutes, the natural period is 6·28 seconds, and $p = 1{\cdot}306$, makes the ratio of the amplitudes with and without the obstruction equal to 1·020.

With a 75-per-cent. obstruction $\gamma - \gamma_o$ is 18 degrees 30 minutes, the natural period is 6·60 seconds, and the value of p is 2·165 ; making the calculated mean amplitude 3·2 per cent. less than without the obstruction.

The relations between the observed effects of these obstructions on the amplitude and those calculated in this way from the observed lags and periodicities are shown in the following Table :—

Obstruction : percentage of waterway.	Effect on mean tidal range above obstruction : per cent.	
	Observed.	Calculated.
30	+1·8	+2·0
50	+2·4	+2·7
75	−3·5	−3·2

CONCLUSIONS.

The results indicate that an increased constriction in the waterway of a tidal estuary does not necessarily involve a diminution in the volume entering and leaving the upper estuary per tide ; on the contrary, in estuaries of the type and proportions examined, a constriction of section up to a certain point increases the level of high water at all points above the constriction and increases the volume entering and leaving.

The effect of considerable percentage constrictions on the levels of high water and low water and on the tidal range is shown to be somewhat surprisingly small. Thus, in the case of the Severn estuary with an artificial obstruction at Beachley, the effect on the mean tidal range in the upper estuary at spring tides was less than 3 per cent. so long as the obstruction did not exceed 70 per cent. of the waterway.

With such percentage obstruction as would be caused by the piers of any normal bridge, the effect on the tidal levels and on the volume of flow is so extremely small that it is inconceivable that it could have any but a local effect on the tidal scour. Where, as in the cases examined, such an obstruction increases the volume of flow, its effect, if any, should be beneficial rather than the reverse.

The results would also appear to be of interest as indicating that, for such an investigation as that in question, where movement of bed-materials is not involved, a comparatively small-scale model is capable of giving results with a sufficiently high degree of accuracy. They also point to the danger of attempting to predict, without the use of a model, the probable effect of any modification in the case of such a complex system of forces and interactions as occurs in estuarine flow.

ADDENDUM.

Since the previous section of the Paper was written, the following additional evidence bearing on the question has become available.

Experiments on a Small-Scale Model of the Estuary of the Dee.

A model to a horizontal scale of 1 : 40,000 and a vertical scale of 1 : 400 has been constructed of the estuary of the Dee. This includes a portion of Liverpool Bay extending 4·5 miles seaward of a line joining Point of Air and Hilbre. It differs from the larger model of the Dee, previously referred to, in that the latter also included the estuary of the Mersey and a much larger area of Liverpool Bay.

Experiments on this smaller model show that an obstruction similar to that in the larger model, and obstructing 74 per cent. of the waterway, lowered the mean high-water level at spring tides by 1·0 foot, whilst a 66-per-cent. obstruction raised the high-water level by 4 inches, results which are in agreement with those from the larger model. An obstruction of 35 per cent. blocking up the Hilbre Swash on the northern side of the entrance increased the high-water level at Connah's Quay by 8·0 inches, whilst an obstruction of the same size blocking the entrance to the Mostyn Deep on the southern side of the entrance had no measurable effect on the level. The two obstructions together lowered high-water level by 4·5 inches.

Experiments on a Large-Scale Model of the Estuary of the Dee.

Experiments are at the moment in progress in the Author's laboratory on a larger-scale model of the Dee to a horizontal scale of 1 : 5,000 and a vertical scale of 1 : 200. The effects of certain schemes of double training walls below Connah's Quay have been investigated. In one such scheme the reduction of the width between the walls from 600 feet to 300 feet increased the high-water level at Connah's Quay by 0·7 foot without affecting the level of low water.

Experiments on a Model of the Estuary of the Humber.

Some 7 years ago a model of the estuary of the Humber, extending from a point 2 miles seaward of Immingham to points on the Ouse and Trent about 20 miles above the junction of these rivers, was constructed in the Author's laboratory for the purpose of investigating the probable effect on tidal levels, currents, and on the conformation of the bed, of the piers of a proposed bridge between Barton and Hessle, about 6 miles above Hull. This bridge was to have sixteen piers, which would cause an obstruction of approximately 4·5 per cent. to the waterway at high water of spring tides. The model had a horizontal-scale ratio of 1 : 7,040 and a vertical-scale ratio of 1 : 192.

Experiments showed that the effect of the piers on the tidal levels was too small to be measured with any accuracy, and the same applied when the piers were widened so as to obstruct 8 per cent. of the waterway.

At a later stage the effect of large obstructions at the bridge-site was investigated. In the first experiment the main span of the bridge, 924 feet in length, was entirely blocked ; following this an additional length of 760 feet on the south side of the main span was also blocked. These obstructions reduced the area of waterway at high water of spring tides by about 30 per cent. and 43 per cent. respectively. The effect of the 30-per-cent. obstruction was to reduce the high-water level at spring tides at Goole by approximately 0·1 foot, and to raise low-water level by the same amount, the effect at points nearer the bridge becoming progressively less. With the 43-per-cent. obstruction the high-water level at Goole was reduced by 0·3 foot, and the low-water level was raised by 0·2 foot.

In this general connexion the following quotation from p. 181 of "Tidal Rivers," by W. H. Wheeler, is of interest :

"At Shoreham, the widening and deepening of the harbour mouth resulted in depressing the rise of spring tides from 18 feet to 16 feet. At Newhaven also the works carried out for improving the entrance to the harbour, although causing the tide to be earlier, have made the rise 2 feet less than formerly."

The Paper is accompanied by eight sheets of drawings, from which the Figures in the text have been prepared, and by one photograph.

Dredging Operations in the Port of Londonderry.

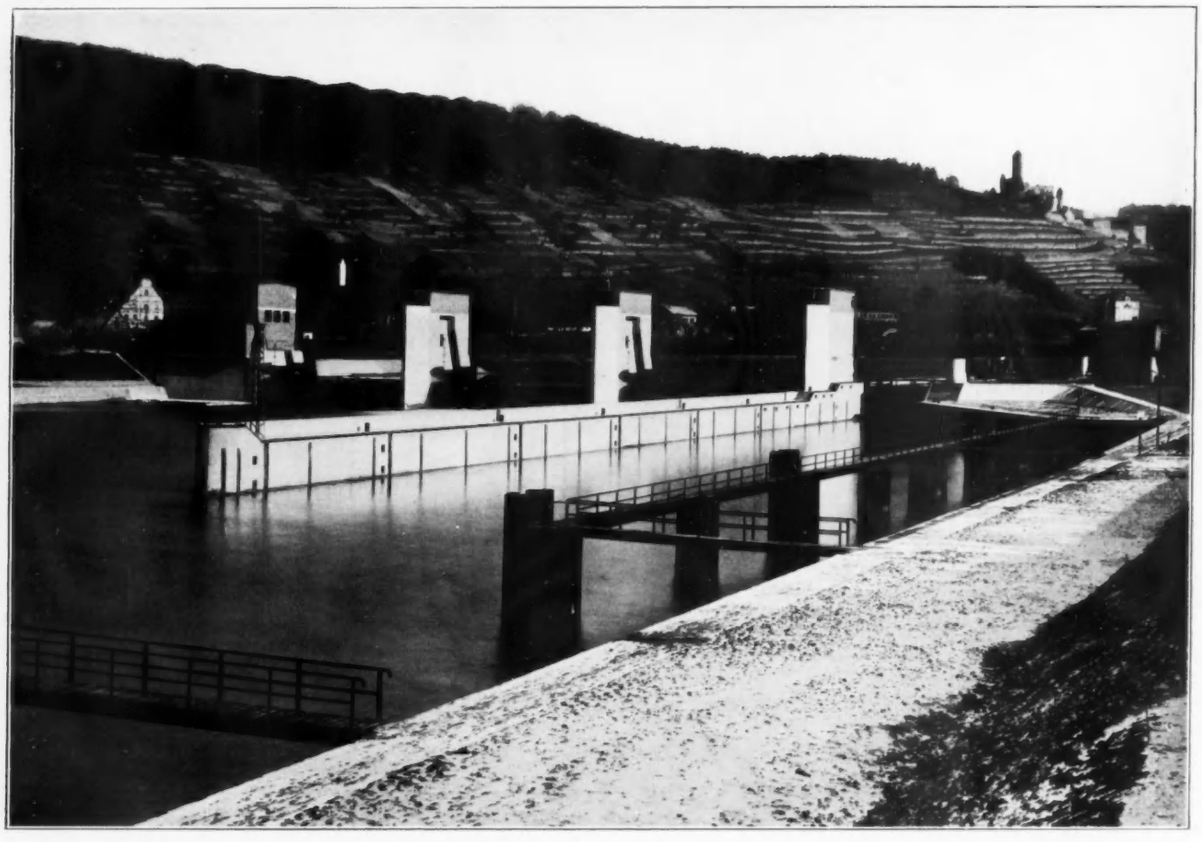
The Londonderry Port and Harbour Commissioners have awarded an important dredging contract to Messrs. Tilbury Contracting and Dredging Co., Ltd., for extensive dredging operations in the Port of Londonderry and Lough Foyle, in connection with the improvement of the navigable channel between Londonderry and the sea.

Trade Increase at Gdynia.

The trade turnover at Gdynia during 1937 totalled over 9,000,000 tons, representing an increase of 14 per cent. on 1936, when the total was 7,743,395 tons. An improvement is recorded in both imports and exports, the figures for 1936 and 1937 being 1,335,255 and 1,718,000 tons respectively for imports and 6,407,920 and 7,288,172 tons for exports.

Thames Barrage Enquiry.

As we go to press we learn that the Thames Barrage enquiry, which was to be held on the 29th and 30th March, has been cancelled on the instructions of the Ministry of Transport. The Minister stated that the Government had recently had before them a report of the Committee of Imperial Defence to the effect that, from the defence aspect, the construction of a barrage across the Thames would have very serious disadvantages.



Weir and Lock in the Canalised Neckar.

German Inland Waterways and Harbours Developments during 1937

(Translated from the official Report of the Reichsverkehrministerium).

I—Canals and Inland Waterways

Administration of the State Waterways during the Year 1937

During the year 1937, the Authorities entrusted with the administration of the State Waterways have made progress in the realisation of their programme which aims not only at increasing the revenue from the waterways and from the cultivation of the land, but also at developing the efficiency of the German rivers by subjecting them to more careful supervision and by the construction of waterways and by linking up important economic areas with the great rivers by means of service canals. In addition to the constructional undertakings thus necessitated, their operations further embraced the maintenance and expansion of the harbours and the sea-water channels—improvements in beacons and marine signalling, in the conservancy of coasts and islands and, lastly, in the installation and upkeep of efficient waterway appliances, vessels and other equipment.

The following is a detailed report of operations carried on in the several river and coastal areas and of other undertakings initiated during 1937:—

Rhine—Main—Danube Basin

The conservancy operations carried out on the Rhine from Kehl to the Dutch frontier were limited to the maintenance of the Rhine waterways and to operations for improving and ensuring the fresh water flow. Above Kehl, a further regulation of the neap tides of the Upper Rhine rendered it possible to increase the depth of the navigable water so that vessels plying on the Rhine and also in the interior of Germany can participate more and more in the prospering goods traffic of Bâle Harbour.

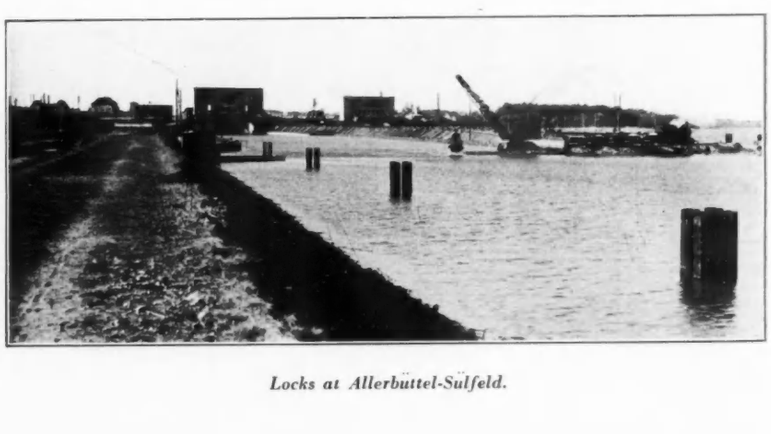
The completion of the first stretch of the Rhine-Main-Danube netway has advanced so far that large ships will be able to reach Würzburg in 1938. To facilitate the passage for larger vessels, the locks between Frankfurt and Aschaffenburg have been remodified to meet modern requirements, while the increased power-consumption has rendered it possible to speed up the enlargement of the seven remaining Main power stations between Aschaffenburg and Würzburg, at which, so far, no work has been possible owing to difficulties in the delivery of materials. From the extensions at these stations, an output of approximately 140,000,000 K.w. may be anticipated in the course of the year.

On the Neckar Waterways the year 1937 was spent, primarily, in making preparations for extending the canal system as far as Plochingen. The final stage of the great flood-tide barrages in the vicinity of and below the town of Stuttgart which form an integral part of the extensions of the Neckar, is so far advanced that the major operations will be completed in 1938.

Canals in Western Germany

For the extensions designed to be carried out on the Dortmund-Ems Canal, a first large instalment of 24,000,000 Reichsmarks was earmarked in the budget for 1937. The operations on the Southern section have advanced as far as Bergeshövede and on the Northern side, on the Ems lateral canal planned between Hesselte and Papenburg, have been initiated on a large scale. The working plan originally contemplated for 1937 could not be completely accomplished, but there is every prospect that arrears will be made up during the Budget year 1938.

On the Rhine-Herne Canal extension, operations have been undertaken in connection with the construction of a State autotrack that crosses the Canal to enable the canal, in this locality, to allow of the passage of three vessels at a time.



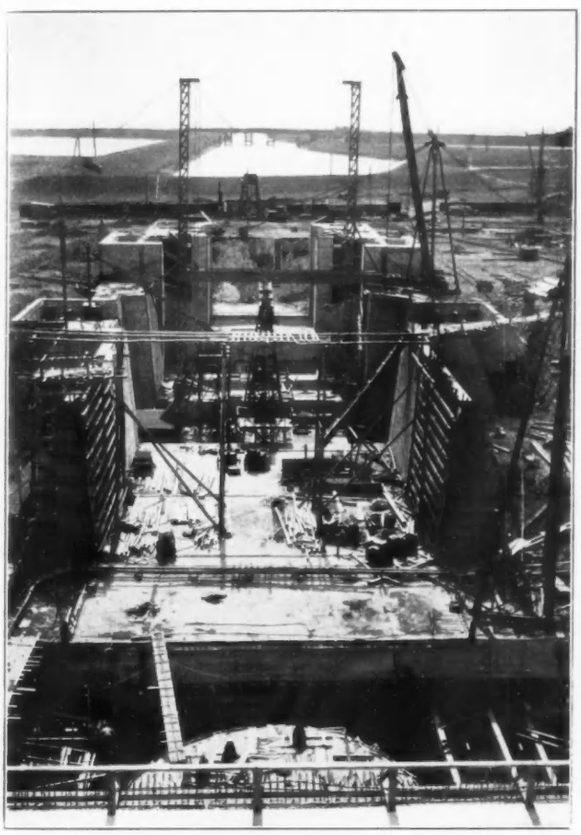
Locks at Allerbuttel-Sulfeld.

German Inland Waterways and Harbours Developments—continued

Weser Basin

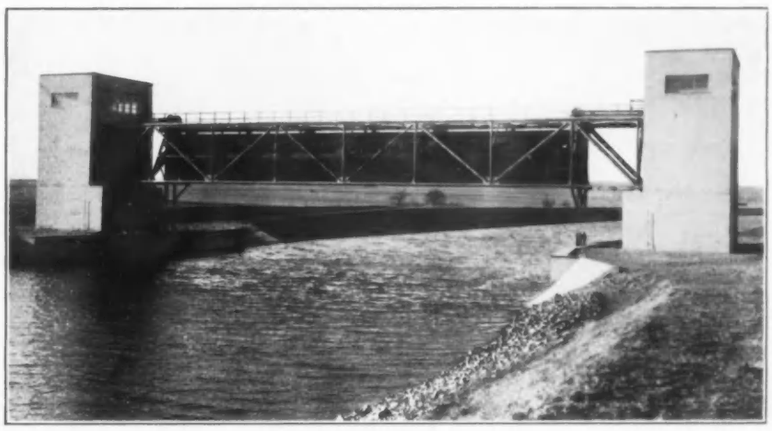
The canalisation of the middle section of the Weser from Minden to Bremen so as to accommodate vessels of 1,000 tons by which, in the first instance, a completely satisfactory waterway connection with the Midland Canal at Minden and also with the Rhine-Westphalia industrial area, can be established, was definitely planned and estimated for, last year. Operations are in full swing over practically the entire length. The reinforcement of the river banks to meet the increased hydrostatic pressure due to the five new barrages at Petershagen, Schlüsselburg, Landesbergen, Drakenburg and Langwedel has been practically completed. These operations consisted in raising the level of the land flanking the banks and the formation of embankments and retaining walls. The lock canals of the Petershagen and Drakenburg barrages are, for the most part, ready for service, several bridges across these canals being also completed. A start has also been made in sinking the central pier of the Drakenburg barrage, while at the Langwedel barrage a considerable part of the ground operations for the lock canal and a massive dam have been carried out. The preparatory operations for the barrage stages at Schlüsselburg and Landesbergen have advanced so far that in 1938, these works will also be taken in hand.

The neap tide control of the Upper Weser (Münden to Minden) was continued. The working efficiency of this reach was increased still further by the supply of additional water from the Edertal dam.



Rothensee Lift under construction.

In the autumn of 1937 a start was made in the canalisation of the Werra over the stretch between Münden and Wartha, a length of roughly 100 kilometres (62½ miles). The canalisation of the Werra by which the Weser navigable waterways are extended southwards, provides, first and foremost, for the potash industry which has its home on the Werra and requires facilities for export abroad, a means of linking-up with the waterway system of Germany. On November 1st the first new Board of Works was installed in Münden, and, on the same date, a preliminary Works' Office was set up in Eisenach to which was entrusted the working out of a finished plan for the canalisation of a central stretch of the Werra, from Wartha to Merkers, roughly 50 kilometres (31 miles) in length.



Closing Door of the Lock at Neuhaldensleben.

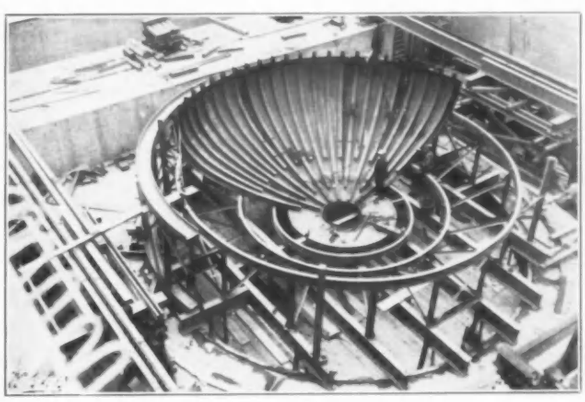
With a view to facilitating the rise in the water-level of the Ems-Weser Canal, which is indispensable for the navigation of vessels of 1,000 tons, large-scale operations were undertaken to reinforce the canal dams and to raise the embankments and their abutments to a higher level.

The Elbe Basin: Neap-Tide Control of the Elbe

The contemplated extension of the Elbe from the State frontier to the Seeve Estuary which was initiated in 1935, is progressing satisfactorily and steadily; practically a third of the distance has been completed.

Barrage Structures on the Elbe at Magdeburg

The rock strata in the Elbe occurring inside the town of Magdeburg do not, as with the other stretches of the Elbe, allow of the river bed being shaped to a depth adequate for the yearly water requirements. A dam construction has, accordingly, been



Foundation of the Rothensee Lift.

put up in the Elbe below Magdeburg, which, however, is only made use of in periods of drought. Vessels plying on the river then pass through a side canal and clear the falls with the aid of an extensive system of locks. The construction of these locks was commenced in 1937.

Midland Canal—Main Canal

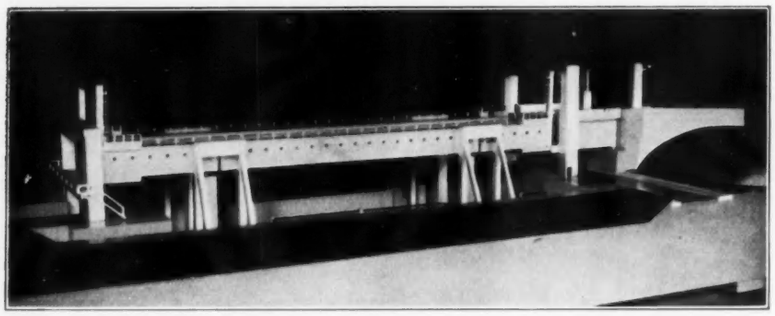
On the Weser-Elbe stretch of the (Nuttel-land) Midland Canal, the Allerbüttel-Sülfeld locks have been completed so that with the opening of the year 1938 onwards, the navigation of the Canal as far as Neuhaldensleben will be feasible. To all appearance also, the elevator or lift at Rothensee which is approaching completion will be put in service by the end of 1938 and the inter-linking of the waterways of West and East Germany will be established.

A beginning has also been made with the building of canal bridges over the Elbe, and the completion of these is expected in 1942. The construction of the duplicate elevator system at Hohenwarthe has made satisfactory progress and the floating shafts have been sunk as far as the " Moraine " level.

Extension of the Saale

In the extension operations now in progress on the Saale, the construction of the lock by-pass at Alsleben is being continued

German Inland Waterways and Harbours Developments—continued



Model of the Rothensee Lift.

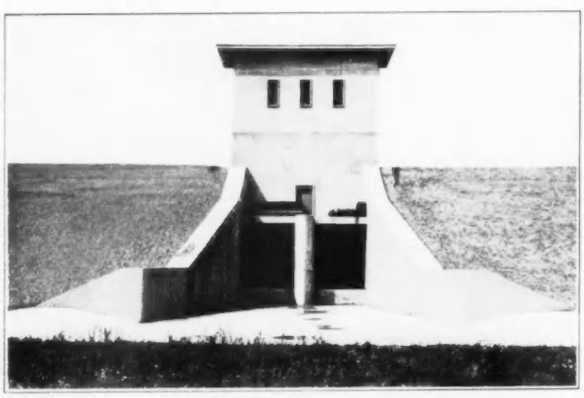
and a start has been made with the erection of the Merseburg and Calbe locks. The locks at Bernburg and Rottenburg have been completed as far as the installation of the lock-gates.

The Elster-Saale Canal

In the operations connected with the Elster-Saale Canal, the construction of the lock-stages at Wüsteneuch and the constructions for the gradient of the Elster-Saale Canal down to the Saale have been put in hand.

Hohenwarthe Valley Barrage

Constructional operations in the Saale Valley at Hohenwarthe are making satisfactory progress, and up to the close of 1937, approximately 200,000 M³ of concrete has been incorporated in the barrage walls.



Discharge Sluice in the Midland Canal.

The Bleckenstedt-Hallendorf Shunt Canal

By way of linking up the new mining plant to be installed by the "Hermann Göring," Reichswerke A.G, with the Midland Canal, an offshoot canal of 18 km. (11¼ miles) is being planned. This offshoot canal will branch off, west of Brunswick, from the Midland Canal and will rise by two lock stages of 9.0 metres each, to the level of the mining plant to the east of Bleckenstedt and Hallendorf. The last 3 kilometres of this canal are to be widened out so as to form a transfer dock. The preparatory operations have been begun, so that the building proper can be taken in hand with the opening of 1938.

Mark and Mecklenburg Waterways

The new building operations on the Mark waterways were, during 1937, classified under the following main sub-divisions:—

1. Extensions and additions to existing plants.

2. Conversion of the Berlin waterways with reference, more specifically, to the re-designing of the Berlin building scheme and the diversion of the Midland Canal traffic to Berlin waters.

3. The inception and execution of measures relating to river finance.

1. In addition to a series of minor matters, a major undertaking includes the reconstruction of a second lock at Lehnitz, by means of which the Western gradient from the water shed of the Hohenzollern Canal may be brought to the same standard of efficiency as the western descent at Niederfinow already enjoys. The reconstruction of the lock may in accordance with the plans, be accelerated.

2. The elaborate scheme for the rebuilding of Berlin which has been entrusted to the Inspector-General of Buildings for Berlin, involves also an unconditional redrafting of the routes of the city's waterways. In other words, it is imperative that these waterways should be rendered navigable for the larger craft of the Midland Canal (1,000-ton boats). For the preparatory and subsequent work in connection with these extensive undertakings the State Waterway Board have set up a special New Buildings Department under the supervision of the Oberpräsident of the Province of Brandenburg (Kurmark River Buildings Management).

Among the undertakings the execution of which is projected, the reconstruction of the Mühlendamm barrages, which constitutes part and parcel of the hygienic improvements to be effected in the heart of the city, would mark a distinct step forward.

3. The carrying out of the financial schemes relating to the State Waterways of the Mark has, of recent years, assumed increasing importance. The Board of Administration devotes more and more attention to these problems which are entirely separate from the traffic requirements. The erection of the Gnevsdorf flood-gate at the mouth of the Havel which will provide the inundation outlet so urgently required in the interests of agriculture along the lower course of the Havel, has been taken in hand. With a view to improving the route taken by the Spree in Berlin and the protection of the Spreewald from inundation, preliminary investigations are to be undertaken in Fürstenwalde by a Board set up for the purpose, the expenses incurred being defrayed by the Prussian State, the Provincial Union of Brandenburg and the City of Berlin, conjointly.

As forming part of the Mecklenburg waterway operations work has, for a long time, been in progress for the improvement of the Elde waterways. As part of the programme for these improvements, the rebuilding of the Parchim locks was taken in hand in 1937. The new lock-gates here installed were of dimensions adequate for the Saale traffic (craft of 400 tons).

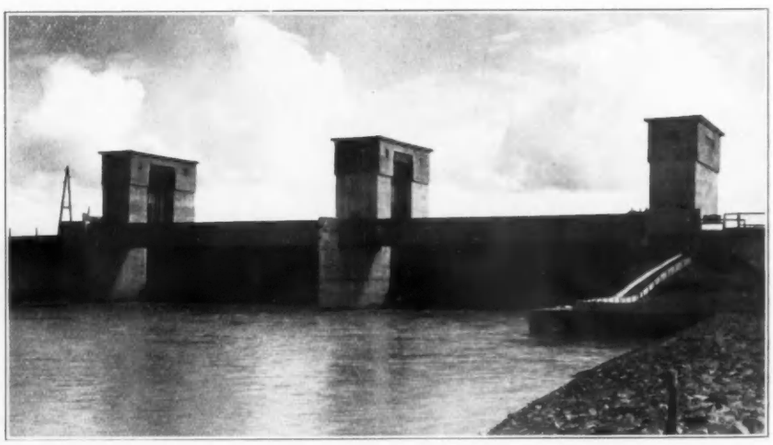
Oder Basin

The improvements carried out on the Oder Waterways below Breslau and as far as Lebus (333 km.) included levellings and, the erection of embankments and abutments, etc. More specifically, sharp curves which would impede navigation such as those at Laskau were eliminated by straightening out.

In the Basin of Turawa Barrage at the Malapane which, like the Ottmachau Valley dam on the Neisse Glacier, completed in 1933, is intended for storing the addition water for the Oder waterways has been so far advanced that a start can be made with the storage of the water in the basins which are of approximately 90,000,000 M³ capacity. The hydraulic power plant connected with the discharge vullets will come into operation within a short time.

The first of the three storage basins envisaged over the Klodnitz at Stauwerder is all but completed so that a start can be made in the storage of the water (10,000,000 M³ capacity).

The constructional work in connection with the storage reservoirs of 65,000,000 M³ capacity projected at Berghof in the Weistritz Valley was started in the autumn. The first operation was the displacement of the railway track between Metkau and Ingramsdorf, including the station of Metkau.



Dam on the Lower Havel.

German Inland Waterways and Harbours Developments—continued

Further progress has, in accordance with the contract, been made in the construction of the Adolf-Hitler Canal which connects up Gleiwitz with Kosel. All the barrages (six double gates) have been put in hand and are, in part, completed. The ground excavations for the canal bed as also the engineering erections (bridges, weirs, etc.), have been, for a great part, completed.

At the same time, the constructional works in the harbour of Gleiwitz have been prosecuted further. The basins have been excavated and rail tracks laid down. Tracks for coal conveyors and cranes have been ordered. It is anticipated that the harbour and canal will be opened in the course of 1939.

In order to protect Ratibor from inundation, the course of the Oder has, for a stretch of 8 kilometres (5 miles) been diverted eastwards, away from the town. The ground operations are, practically, half completed. A road bridge has been erected and the piers for a new railway bridge constructed.

Double Lock at Stauwerden.

East Prussia

The construction of the Masurian Canal by which it was intended to establish a navigable waterway connection between the Masurenland Lakes and the Pregel Basin and so join up Masurenland with the harbour of Konigsberg, continued to be prosecuted, and the completion of the canal is looked forward to in 1939. The final constructional works comprise the remaining ground operations and the erection of three locks, namely, those of Klein-Bajoren and of Upper and Lower Fürstenau.

In the year 1924 a temporary bridge was built over the Deime in Tapiau to replace the bridges destroyed in the War and this bridge has now during the past year been superseded by a new and very substantial one. The new bridge has two archways of roughly 15.80 metres, in one of which is fitted a single-wing swing-gate.

(To be continued).

German Inland Shipping in 1937

Increase in Total Volume of Cargoes Handled

The Commercial Counsellor, His Majesty's Embassy, Berlin, reports the following summary of the provisional report issued to the press on German Inland Shipping in 1937:—

German inland shipping had a prosperous year in 1937 and in some cases the former peak figures of 1929 were exceeded. The increased activity considerably alleviated the position of inland shipping. Freight rates were, however, kept at a low level and prevented a great financial improvement.

As a result of the price control regulations there have been few changes in freight rates except in Rhine shipping. A new freight committee was formed at Dortmund for West German canals.

The working capital of inland shippers showed little increase last year. There was a tendency towards motorisation and power-driven barges. New constructions were influenced by the control of raw material supplies, but the regulations against increasing tonnage were relaxed for the Elbe, the Oder and canals in Central Germany in the Spring without making difficulties. Further facilities for building are being examined.

The total volume of cargoes loaded and discharged from January to October, 1937, rose by 13 per cent. compared with the same period of the preceding year. Traffic was particularly heavy on the Rhine, where there was an increase of 27 per cent.; at the end of October traffic returns had exceeded the figures for the whole of 1936 by 2 million tons. Outgoing and incoming shipping at the frontier Port of Emmerich was about 32 per cent. higher than in the first ten months of 1936, and shipping at Duisberg improved by 38 per cent. Shipping on the Neckar rose by 44 per cent. compared with 1936. There was a slight decline in shipping through the Dortmund-Ems canal, which was closed for repairs for nearly two months, but a corresponding improvement took place on the Lippe Canal where part of the traffic for Dortmund was diverted. Traffic through the Weser lock was affected by low water periods and fell off by 7 per cent.; coal cargoes for Bremen were despatched to a greater extent via the Coast Canal. The increases on central German and eastern waterways were less marked; traffic on the Upper Elbe rose by 11 per cent., at Cosel by 18 per cent., and for Berlin and Konigsberg by only 1 per cent. Owing to increased imports of grain from the Danubian countries, shipping in Danube harbours within Germany was doubled compared with the first ten months of 1936.

Although total traffic is reported to have fallen off during the last weeks of the year, it is estimated that the total figure for 1937 will be about 10 per cent. higher than in 1936.

The Government credit which was granted to inland shipping in the form of loans through three ships' mortgage banks in 1926 has been prolonged by a further ten years.

Fremantle Harbour Trust, Western Australia

Excerpts from the Thirty-eighth Report of the Commissioners for the Year ended 30th June, 1937

Financial

The Revenue Account for the year discloses that the gross receipts totalled £472,855 8s. 5d., an increase of £30,037 16s. 10d., or 6.8 per cent. over the previous year, while working expenses, at £221,157 11s. 4d., were £16,628 14s. 6d., or 8.1 per cent. in excess of last year.

The principal items of revenue in which increases have occurred are Wharfage £17,123, and Surtax £3,431, Harbour Improvement Rate £2,674, and Crane Hire £1,425, all of which may be attributed to the greater volume of inwards cargo. The increased receipts under Handling Charges £4,801, and Wharf Labour Recoups £4,483, are more than accounted for by Wharf Labour Wages, which this year exceeded by £9,812 the corresponding item for last year. Decreases in revenue are noted in respect of Tonnage Rates £1,115 (the gross aggregate tonnage of vessels using the port being 232,110 tons less than last year, owing chiefly to the decrease in wheat for export), and Storage £1,974.

As regards expenditure items, Insurance is higher by £959, owing to the increase already referred to in Wharf Labour Wages, the several maintenance items by £962, in the aggregate, and Crane Expenses and Maintenance by £1,327, corresponding with the increased revenue from this source.

The surplus of gross revenue over working expenses was £251,697 17s. 1d., or 8.7 per cent. of the total capital indebtedness, as compared with 8.1 per cent. last year. After allowing for payment of interest, sinking fund and renewals fund, the surplus then remaining, £98,387 17s., represents 3.4 per cent. on capital, against 3.3 per cent. last year.

Wharf Reconstruction

The reconstruction in hand at the east end of Victoria Quay is now almost complete, and it is expected that the berth at " H " Shed will thus be available at an early date. The whole of Victoria Quay will then have been reconstructed.

Dredging

The ordinary dredging necessary to maintain a depth of 36-ft. below low water throughout the Inner Harbour and Entrance Channel was continued throughout the year. The anticipation expressed in our last report that the widening or " bell-mouthing " of the seaward approach to the Entrance Channel would have been commenced during the year was not realised, but it is hoped that this work will be put in hand in the near future.

The Report is signed by Mr. Tom Carter, the Chairman.

Belfast Harbour Airport

A New Field of Harbour Enterprise

The Official Opening of the Belfast Harbour Airport by Mrs. Neville Chamberlain took place on the 16th March. The imposing hangar, of a million cubic feet capacity, in which the ceremonial proceedings were held, stands on land that 16 years ago was under 6-ft. of water at high tide.

The airport had its origin in the dredging operations of the Belfast Harbour Commissioners, who in the nineties of last century had two hopper dredgers continually at work to keep clear the channel from the River Lagan to the open sea. Each dredger spent five hours going and coming to and from the sea for every two hours of actual dredging operations.

When the Commissioners in 1921 undertook the construction of a berth and channel for the oil trade, adjoining the Musgrave Channel, they were faced with the necessity of moving $1\frac{1}{4}$ million tons of spoil, later increased to close on 7 million tons by the subsequent development of the Herdman Channel and Pollock Dock. It was realised that the clearance of this great mass—consisting mostly of a sticky grey clay locally known as "sleetch"—by the methods then in use would take too long.

To meet the need for rapid clearance the Commissoiners adopted new methods, the dredgers, instead of journeying to sea, being made to discharge their spoil overside into barges from which the material—a mixture of sleetch, sand, clay and silt—was later pumped to the landward side of retaining banks. Although the cost of this method was higher than that of simple dredging and depositing the spoil at sea, it was more than offset by the facts that dredging could proceed continuously and that a valuable land asset was being created.

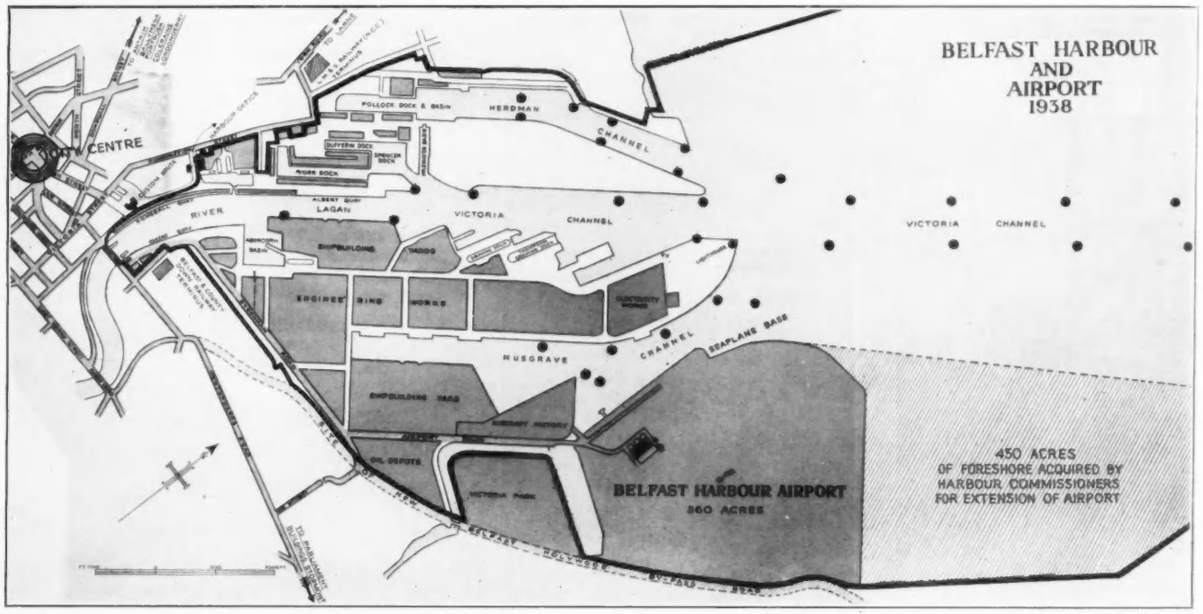
When this work was begun there was no idea of utilising the reclaimed area for any particular purpose, its possibilities as an aerodrome being visualised with the later development of air transport.

The reclamation is now no less than 365 acres in extent, practically all of which, in due course, will be included in the airport. The existing aerodrome licence, received from the Air Ministry last September, relates to an area of 103 acres. This gives ample runways in all directions, and will shortly provide for a fog-runway 400 yards wide and 1,500 yards in length as larger areas are brought into airport use.

The transformation of this great area from a quagmire to a beautifully firm, level surface, is an achievement of which the Harbour Commissioners, their General Manager, Mr. M. J. Watkins, and their Engineer, Mr. W. Y. Chamberlain, can be justly proud. The first part of the dredging was carried out in 1921 by a Dutch firm of dredging specialists. Since that date approximately thirteen million tons of material have been dumped over the 365 acres, to an average depth of 12-ft. over the entire area.

The greater part of this material consisted of "sleetch," but vast quantities of rubbish from the harbour itself, and from the dumps of the Belfast Corporation, as well as fine cinders from the Belfast Electricity Works. have also been utilised.

One of the greatest difficulties with which the engineers were faced was that of binding the surface of the newly-won land. Professor Mercer of the Northern Ireland Ministry of Agriculture, was called in to advise on this problem. His analysis of the soil showed such a high degree of salinity as to make it appear unlikely that plant life could flourish. After repeated tests, however, it was found that rye grass, with a slight admixture of yellow clover would take a hold. The only other plant that would meet the circumstances was a wild local grass—"poa maritima." The seed of this being unobtainable commercially, the Commissioners have produced their own for the past three years, sowing it on the untreated areas to make a first film bed. The procedure has been to follow this by spreading a drainage layer of sand, some 4-in. or 5-in. deep, which in turn is covered first by layers of town refuse, mostly coarse cinders with a final covering of fine clean cinders from the Power Station. On this foundation the rye grass and clover take a firm hold, yielding a tough herbage which binds the surface firmly. The cultivation of the grass will need to be continued for many years to come. It is hoped, as the land ages, to turn it over to finer growths which will make easier the task of cutting.



Up to the end of 1937, 47 miles of agricultural drain pipes had been sunk to carry off excess moisture. The work of laying these pipes, which lie from 18-in. to 7-ft. below the surface, is still proceeding. It has been a task of difficulty, as in the early stages it was found that the empty pipes tended to float to the surface, which necessitated the use of piles to keep them anchored at proper depth. It may be noted that when a trench is sunk to take these pipes it is refilled, not with the gummy "sleetch" dug out of the trench, but first with layers of hay (produced from the airport's own grass) and then with refuse and cinders. Although those parts of the surface over the drain pipes are constantly watched to guard against their sinking, there has been no general subsidence of the airport surface, the rapid hardening of which is indicated by the fact that it now takes a roller drawn by a heavy tractor, whereas a few years ago it would carry nothing heavier than a horse.

As the airport now stands, after the expenditure of close on £100,000, and situated as it is at the head of Belfast Lough, it forms a perfect base for both land and sea-planes. In addition, it has the unique advantage of being within the boundaries of its parent City and only seven minutes' drive by car from the centre of Belfast. In this respect, it may be compared with the aerodrome of Newark, in New Jersey, one of the most up-to-date American airports and one comparable in size. The Newark aerodrome is 35 minutes' drive from the centre of New York, and the passenger who goes to the aerodrome from the City by taxi finds that he has run up a bill of £1.

The development possibilities of the airport fall under three main heads, of which the first is Civil Aviation. The official opening was the occasion for the departure of civil passenger planes on their first schedule flights from the Harbour Airport to Glasgow and the Isle of Man. The second field of aerial activity will be the testing of aircraft produced by the newly-founded firm of Short and Harland, for the transport of whose land machines to the aerodrome a special bridge has been constructed. Thirdly, the airport becomes the home of a Royal Air Force Volunteer Reserve Training School, and will thus play its part in meeting the nation's service requirements.

Although the airport has not yet received a licence for night flying, it is expected that the Air Ministry will shortly be authorising its use for this purpose, for which it is fully equipped with boundary lights, obstruction lights, landing flood-light and illuminated wind tee.

The Thames Barrage

Owing to the necessity of going to press some days before the close of the month, we are debarred from reporting in this issue the proceedings at the Inquiry held on March 30th and 31st by Sir Henry Maybury into the proposal for a barrage across the Thames. We have already commented at some length in our issue of July last year, on the general subject of a Thames Barrage, but hope to deal more effectively with the whole matter after hearing the evidence and statements put forward at the Inquiry. Meanwhile, it may be of interest to give the following particulars of the schemes which have been submitted to the Port of London Authority for consideration, in response to their invitation in the press.

The Thames Barrage Association have submitted a scheme for a barrage to span the river at Woolwich. The width between abutments at the barrage site is 1,500-ft., and within this width, space has to be found for locks and sluices. Seven locks are provided for—one 90-ft. wide by 650-ft. long; two 80-ft. by 550-ft., and four 60-ft. by 450-ft. Allowing for the piers between these locks, the length of barrage occupied will be about 700-ft. The assumption is made that six locks would be in continuous use, and it is claimed they should be able to cope easily with the traffic of the future. This would leave one lock in reserve to allow for contingencies due to accident, annual repair and overhaul, etc. The locks would permit the passage of vessels drawing 30-ft. As the locks take about 700-ft. length of the barrage, there would be about 800-ft. of the barrage left to accommodate the sluices, of which some 500-ft. at least could be actual waterway, if required. The design provides foundations for a viaduct 40-ft. wide for road vehicles, and allows for a double line of traffic in each direction which would pass over the locks at a height of about 60-ft. above T.H.W. Small vessels using the small locks could pass under the viaduct at all times without interruption of the traffic over the viaduct. The design also shows foundations for a viaduct for rail traffic at a level of about 7-ft. above T.H.W.

Messrs. S. R. Broderick and W. E. Brown of Westminster, S.W.1, have submitted a scheme which they estimate would cost about £3,056,000. They propose a barrage 1,700-ft. in length situated in Bugsby's Reach, between a point of 1,150-ft. below the entrance to the Royal Victoria Dock on the north bank and 950-ft. below the coaling jetty of the South Metropolitan Gasworks on the south bank. Combined with the barrage, a ship canal would be cut through the isthmus of land formed by the Blackwall and Bugby's Reaches, 350-ft. wide and just under one mile long, complete with five locks at the down-river end. The locks would be as follows: One 700-ft. long by 80-ft. wide; two 400-ft. by 65-ft., and two 150-ft. by 30-ft. A tunnel would be constructed under the canal to take a 36-ft. roadway with a 5-ft. pavement on each side to serve the Blackwall Tunnel and the road over the barrage when that is completed.

Mr. Albert E. Goodger of Sanderstead, suggests a barrage at Woolwich, extending from west to east, from the dolphin west of the L.N.E. Railway pier for approximately 1,950-ft. eastward to the causeway at the end of Barge House Road. The whole of the river would be filled in from the north bank to the south bank, a distance of 1,500-ft. Running right through the barrage from east to west would be four main locks, the two central chambers being 100-ft. wide, while those nearest each bank would be 80-ft. wide. Each of these four main locks would be sub-divided into four sections of 300-ft., and each section could be emptied or filled separately, and it would thus be possible to lock 16 ships 300-ft. long at one complete operation.

Mr. C. Hamilton Verity of Harpenden, proposes the construction of a barrage, the building of retaining walls and the reclamation of flooded and marshy areas. His scheme provides for the building of a curved barrage at Northfleet, reaching from near Northfleet Lighthouse across to a point near Tilbury Ness. A road and railway would be carried on supports, forming part of the barrage structure, so that road and rail facilities would be provided for cross-river traffic and traffic for the docks and the deep-water jetty. Three new locks are shown, which, with the two existing Tilbury Docks locks utilised, would make in all five locks to cope with shipping requirements. The up-and-down river traffic would have separate entrances to the locks and to and from the river. Two of the new locks at Tilbury would be large enough to allow the largest vessels to pass into the river. The reclamation scheme, based on building retaining walls on both sides of the river from Barking to the barrage, is intended to enable a considerable area of land to be utilised for commercial purposes. It is estimated this scheme would cost about £10,500,000.

Mr. W. H. Bailey of Fulham, proposes to construct near Tilbury a new kind of barrage which in times of flood is to be opened to let out the storm water freely and flush away all silt as the tide runs out, but would automatically close against the returning tide, even if it should rise to 5-ft. above high water level. It is contemplated that ships will be able to pass either way at all times through the two locks provided.

Mr. F. W. Hipkins of Droitwich, has submitted drawings which he prepared immediately after the disastrous flooding in the Thames. They were prepared with the express purpose of preventing river flooding, and have been sent in to assist in dealing with that aspect of the matter only.

Canadian Ports and Waterways

The following extract is taken from the President's address to the members of the Shipping Federation of Canada at the Annual General Meeting held in Montreal on February 9th, 1938:—

Port Operations

Whilst the tonnage of vessels shows some falling off at certain ports, the record, with little exception, is one of increased movement of cargo in and out of our harbours. Grain exports at Montreal and Vancouver, the principal outlets for our export grain, were disappointingly low, especially in the case of Vancouver. Quebec, Sorel and Churchill also registered a lesser movement in grain, whilst Halifax and Saint John, N.B., maintained their grain handling figures of the previous year. At the port of Three Rivers a notable increase in the total volume of export and import grain was a feature of the year's operations. Other classes of cargo were generally heavier, substantial increases being registered by Montreal, Three Rivers, Halifax and Saint John, N.B. Coal imports at Montreal—over three million tons—were somewhat below the figures of 1936, but imports of oil products reached a record figure of approximately two-and-a-half million tons. Exports of cattle from Montreal fell off heavily, only 8,847 head being shipped during the season of navigation.

St. Lawrence Dredging and Water Levels

Substantial progress in dredging the St. Lawrence Ship Channel, and Montreal Harbour, was made during the 1937 season of navigation. The work of dredging to 35-ft., based on the 1897 datum, was practically completed by the close of the season, and after a certain amount of cleaning up work early in 1938 has been accomplished, I think we can rely on a considerable increase in channel depth. It should be borne in mind that this so-called 35-ft. channel project is designed to provide a depth of 35-ft. in Montreal Harbour and in the Ship Channel based on the datum of 1897, but as the level of water dropped more than 2-ft. below that datum in 1934, the project in question cannot be expected to provide a 35-ft. depth in extreme low water conditions.

St. Lawrence Ship Channel—Water Levels Report

Under date January 19th, 1937, the Interdepartmental, Montreal and Ship Channel Water Levels Board submitted its final Report to the Hon. the Minister of Transport, together with its views and recommendations as to the measures that should be adopted to ensure an adequate depth of water in the harbour of Montreal and in the River St. Lawrence Ship Channel between Montreal and Quebec. The Board, organised in January, 1934, had continued its study of water levels since that date, and in its final Report it dealt extensively with the elements entering into the loss of levels during the past forty years, and also with the various measures, such as dams with locks, weirs, and dredging, that have been suggested as solutions of the problem of maintaining an adequate water level in the St. Lawrence River.

In its Report the Board expressed itself as unfavourable to damming and locking measures; moreover, the majority of its members considered that the erection of weirs or training works would not be a satisfactory solution. The majority, in effect, recommended a further dredging programme, with a view to providing a 35-ft. ship channel to Montreal, based on the extreme low water experienced in Montreal Harbour in 1934. Subsequent to the issue of the Report, an announcement was made by the Hon. the Minister of Transport that it was the intention of the Government to proceed with a further dredging programme based on the majority recommendation of the Water Levels Board.

It is our understanding that this further dredging will be carried out with a negligible loss in water levels, and as I think all who are familiar with trade and shipping to the St. Lawrence will agree, there can be no question as to the need for providing a 35-ft. channel from Montreal to the sea, based on the extreme low levels that we have witnessed in recent years. It is gratifying to note, therefore, that the Canadian Government has decided to continue the work of deepening the channel with the object of providing what we hope will be, in actual fact, a 35-ft. ship channel to Montreal.

Foreign Trade Zones

A New Facility for United States Ports

**Address by THOS. E. LYONS, Executive Secretary, Foreign Trade Zones Board, Department of Commerce, U.S.A.*

The waters of our rivers and harbours constitute a national resource paralleling in importance those contained in our land. The development of these waters has produced immeasurable wealth and has made possible the development of other national resources to the present day stages of advancement. Upon the rivers and harbours move a large percentage of our commerce. Inland and off-shore vessels use our waters in the interchange of goods, people and communications. According to the annual report of the War Department, during 1936 a total of 470 million, 500 thousand short tons of commerce valued at 17 billion, 800 million dollars were transported over our national rivers and harbours. It is small wonder that a medium which is involved in the movement of such wealth should merit the attention of all interested in our national economy.

Since water transportation forms a part of the wealth derived from our national waters, and since water transportation is the major method by which foreign trade moves to and from our ports, any improvement in foreign commerce, and in the facilities for its handling, is of paramount interest to you and to me.

During the ten years from 1927 through 1936, our foreign commerce had an average yearly value of 5 billion, 838 million dollars; of this figure, 5 billion, 85 million dollars, or 85.5% moved by water. Comparative 1937 figures are not yet available, but for the first eleven months of 1937, the value of our foreign commerce was 5 billion, 902 million dollars, which, it will be noted, is more than the yearly average for the previous 10 years. In foreign trade, water is necessarily the most important, and usually the only medium by which this commerce is interchanged with foreign countries. It is not necessary to point out the importance of foreign trade to the well being of this country and the necessity for developing and maintaining our ports and waterways to care for this commerce.

Investments in United States Ports

The American Association of Port Authorities, at their convention last October, presented the results of a questionnaire survey obtained from 22 American ports. According to the survey, which was compiled by Mr. Pouder, these ports, which handle approximately 57% of United States water-borne commerce, are credited with having an investment of 3 billion, 400 million dollars in facilities, employing 850,000 persons, and enjoying a combined revenue of 400 billion dollars yearly from their port facilities. It is, of course, regrettable that complete figures for all ports could not have been obtained. However, it is an indication of the huge investment in terminals serving our foreign and domestic water-borne commerce.

A new type of terminal facility has recently been made available to our ports, the purpose of which is to encourage and expedite our foreign commerce. This is the foreign-trade zone, which has had a long and honourable background in Europe, where many of the leading ports are employing it with success in attracting and handling foreign commerce.

The Examples of Hamburg and Gdynia

In Germany there are several free ports, which this country prefers to call foreign-trade zones. The oldest and largest of them is Hamburg which has operated under the German Customs Union as a free port for more than 50 years. Prior to that the entire city had been free to all trade since the era of the powerful Hanseatic League, centuries before. To-day the Hamburg free port covers 3,444 acres with 1,327 acres of water area. It contains over eight million square feet in roofed floor space, and during the first three-quarters of 1937 handled some 18 million, 600 thousand tons of foreign commerce, an increase of 18.4% over the same period in 1936. Hamburg as an example of an outstanding free port is familiar to all of you. The basic operating difference between it and an American foreign-trade zone is that manufacturing is permitted in Hamburg, where some 300 firms make everything from toys to ocean liners. Under the Treaty of Versailles, Czechoslovakia has leased a small portion of the Hamburg free port which it operates as a vestibule for goods destined to and exported from that land-locked country by way of the Elbe River.

The most remarkable example of a modern port is that of Gdynia. Following the War, Poland was re-established as an independent nation, having one port, the Free City of Danzig, to supply its populous hinterland. Danzig proved inadequate in several respects so Poland decided to create an entirely new port, on her own territory a few miles away, on the site of a small fishing village. Work was begun in 1924, and has continued steadily for the past thirteen years. In this short period a tremendous modern port city has been constructed, the population has jumped from 500 to over 100,000. Foreign commerce handled during the first three-quarters of 1937 amounted to some 6 million, 750 thousand tons, an increase of 19% over the same period in 1936. During the same nine months of 1937, 4,171 vessels totalling 4 million, 136 thousand net registered tons entered the Port of Gdynia, a large increase over the same period in 1936.

In the present stage of development, the Port of Gdynia covers 1,668 acres of land, of which the free port occupies 81.5 acres, and 828 acres of water of which the free port occupies 37 acres. There are approximately 2 million, 220 thousand square feet of warehouse space, of which the free port has nearly 600 thousand square feet. The free port was opened in January, 1934, and has experienced a rapid and continued growth in facilities and commerce. Like Hamburg, the Gdynia free port permits manufacturing and indications point to large developments along this line.

History of Free Port Movement

The history of the free port movement in this country properly goes back to 1894 when a bill was first offered to Congress to establish such a facility on Long Island, New York. Active legislative interest began in 1917 with a study of free ports by the newly-created Tariff Commission. From 1918 to 1934, bills for the creation of foreign-trade zones were presented in every Congress. Success came in 1934 with the Cellar Bill which was signed by President Roosevelt on June 18th, of that year, becoming Public Law 397.

The Foreign Trade Zones Board, composed of the Secretaries of Commerce, War, and the Treasury, has been set up to administer this act. Ports of entry are given the opportunity to create, or to allocate existing terminal facilities for foreign-trade zone use. Under specific grant by the Board to public or private corporations, such areas, which are segregated from the customs areas to the satisfaction of the Board, may engage in the handling of import and export commerce including trans-shipments and re-exports.

Advantages of Free Ports

The principal attraction of foreign-trade zones is that foreign merchandise is free from the payment of tariff duties while enjoying the privilege of storage and manipulation while within the zones. Nor is any bond required for the safe-keeping of the merchandise, and the shipper has access to his goods freely during business hours. There are many other attractions which result from the foregoing privilege. Shipside storage may be mentioned as saving many dollars in cartage and handling costs. Freely permitted inspection before acceptance of a shipment by the importer may save many dollars more. Indications are that new uses for the foreign-trade zone will develop, and further benefits to the port, the carrier, and the trader, will accrue as zones are established.

New York was the first port privileged to establish a foreign-trade zone. On February 1st, 1937, an area set aside at Stapleton on Staten Island was opened for limited operation. This zone comprises 18 acres of land and five piers on which are sheds for the storage and manipulation of merchandise. A variety of commodities important in our foreign trade have been brought into the zone for storage and manipulation during the first ten months of operation.

Mobile, Alabama, was the second port receiving permission to establish a foreign-trade zone. When this zone opens early this Spring, it will offer a further testing ground for the principles underlying such customs-free areas. Since that port has practically no re-export or transhipment trade at the present time, it will be interesting to determine the attraction of the zone for this entrepot trade.

Free Ports in Operation

While it is too soon to draw a complete picture of the benefits deriving to American commerce from foreign-trade zones, indications of the possibilities can be obtained from a few of the commodities so far handled in the N.Y. zone. One such commodity was a large shipment of chick peas from Mexico. These peas have a diversified market in this country and in Latin America. In the condition in which they are shipped from Mexico, certain processing must be undertaken before they are ready for marketing. In this instance, the chick peas were deposited in the zone by the vessel bringing them from Mexico. In the zone the peas were fumigated, cleaned in a special machine, graded and repacked. Parts of this shipment were then imported into this country in small lots after payment of the duty. Other parts of the shipment were sold and exported to various markets in Latin America without the payment of American duties or without detailed customs procedure. The operations were simple and enabled the owner to save considerable time and money on the entire transaction.

*At the Thirty-Third Annual Convention of the U.S. National Rivers and Harbours Congress, January 20th, 1938.

Foreign Trade Zones—continued

Other items handled in the zone were picture frames and paintings brought from Denmark to be sold in this country. Arriving in the zone, the frames and pictures were unpacked and examined by department store buyers. These buyers choosing the proper frames for the paintings they purchased, had the importer assemble the frames and paintings in the zone for delivery to the department stores. The transaction was handled very quickly and efficiently in the zone and the importer was highly pleased with the entire transaction.

A further example of what the New York zone is accomplishing is the relabelling of a shipment of Argentine canned beef. This shipment, probably the forerunner of many more, arrived in the zone from Argentine with labels printed in Spanish. It is the intention to relabel these cans and cases with the proper information in English, that they may be sold readily in our markets. Permission has been obtained for this to be done, and the zone has proved one more point to its advantage—that it creates opportunities in the use of American materials and labour.

Time does not permit further illustrations of what the New York zone is actually doing for American foreign trade. In another year still more information will be available with which to judge the foreign-trade zones in New York and Mobile. The point that I do wish to bring out, is that the foreign-trade zone is a further development of our national water resources, designed to promote the commerce which forms such a large part of the wealth of the United States.

Dredging Operations in Great Britain and the Netherlands

A Comparison of National Methods

BY A CORRESPONDENT

In the carrying out of harbour improvement and kindred utility works there is perhaps no more striking example of the policy of departmentalism as opposed to the private contract system than is to be found by a comparison of the administrative means by which harbour authorities, government departments, etc., in this country effect the carrying out of such works, with those adopted in Holland where work of this character assumes the proportions, almost, of a national industry.

The difference is indeed so clear-cut as to suggest a difference, almost, in national psychology, but whether the balance of merit or demerit lies in one system rather than in the other is less the object of the present contribution than a presentation of the facts.

Practice in Holland and Great Britain.

So far as concerns the carrying out, departmentally, of dredging and kindred works in Holland, this system is practically non-existent in that county; the whole of such work, whether for public or private bodies, is carried out by private contract.

In Great Britain on the other hand, the majority of harbour authorities and dock-owning railway companies, with one or two notable exceptions, operate their own dredging plants, departmentally, and only call in the dredging contractor for a piece of extra-normal dredging work, or such work as may necessitate the use of the dredging contractor's special plant.

Such, together with the occasional needs of private firms and harbour authorities owning no plant, constitutes the somewhat limited market for the services of the dredging contractor in this country and is in marked contrast with the conditions prevailing in Holland.

Figures illustrate this difference somewhat strikingly for, whereas, in Holland, dredging-contracting firms number approximately a hundred, owning among them some 300 bucket and suction dredgers and many more hundreds of hopper barges and kindred craft, representing a capital value of over 40,000,000 florins; similar firms in this country hardly number one-tenth of the above figure and, even so, have often enough not sufficient work to keep their plant and appliances in anything like full or regular employment.

The Question of Regularity of Employment

Irregularity of employment is no less common in Holland, but it is of interest to note in passing how the contrast of systems in the two countries affects the question of the availability or non-availability of competent dredging hands, by which is meant "key" men of the status of dredging masters, winchmen and the like.

That there is a constant surplus in Holland is due to the circumstance that even a small unemployed percentage of the vast number of privately-owned dredging vessels there produces many idle hands and, incidentally, constitutes a reserve and ready source of supply for this country where competent dredging hands are hard to obtain.

The scarcity here, where no more than half a dozen principal firms operate, is due in small part only to the limited scope for employment with contractors, mainly, it is due to the fact that harbour authorities in general do not, if they can avoid it, part with their "key" dredging men during slack times, or seasons, and even those authorities who carry out their dredging work during the summer months only and lay up their plant in the winter, prefer to retain their dredging men during such times by giving them jobs ashore.

Contractors have no shore jobs to offer their employees during slack times as the business of contract dredging is not like a manufacturing business which can tide over such times and keep personel together by working short time or by other devices, such as producing for stock. There are no means of keeping dredging crews together since, from the nature of the case, a unit of plant is either in full employment or completely idle. Hence, when times become less slack, contractors have to trust to luck in their search for dredging crews, and are indeed often driven to seek for suitable men in the Dutch market where, for the reasons already stated, skilled men are so much more readily available.

It follows from the foregoing that the employment of the Dutch dredging men does not necessarily spell the displacement of a Britisher since, in general, there are so few out of employment; a recent requirement for a skilled man circulated to half a dozen Labour Exchanges at the principal seaports produced not a single application for the vacancy. There is some reason to believe that the Immigration Authorities are not indisposed to make reasonable allowance for these peculiar circumstances when dealing with occasional applications for permits for the employment of Dutch nationals here.

Exceptional Cases

Reverting to the main theme, "departmentalism" v. "private contract," in dredging matters, there are certain exceptions to the rule in this country; notably the Southampton Harbour Board, as also the Southern Railway Co., the latter of whom entrust all their dredging work at the various ports under their control to a private contractor.

The Port of London Authority adopts the somewhat unique policy of carrying out most of their dredging work, departmentally, whilst giving out their depositing work to contract.

It is not to be doubted that departmentalism in dredging work here in-so-far as it tends towards the elimination, or part elimination, of the dredging contractor must operate at times a little hardly upon those who have no dredging plant of their own with which to carry out occasional dredging requirements.

The Economic Point of View

Where such work is comparatively small and the contractor's plant for carrying it out has to be transported several hundred miles, it may be, along or round our coasts to the dredging site, the cost of such transport may add appreciably to the actual cost of the dredging in terms per cubic yard dredged and deposited.

With larger quantities, however, transport costs shrink proportionately to total cost, but, in all circumstances, the cost of transport over considerable distances is far from negligible.

In this case, at any rate, upon a comparison of national methods, the advantage would seem definitely to lie with the contract system obtaining in Holland, where it may be said, with a near approach to truth, that there is a unit or are units of dredging plant available at every port and another round every river bend, resulting to the advantage of those requiring a piece of dredging work, whether large or small, plus elimination, largely, of transport costs from the dredging bill.

However much they may desire to do so, contractors here cannot dot our coasts with dredging units at convenient points for all unless they are given the requisite encouragement to do so by harbour authorities.

Whatever may be the case for or against departmental dredging at the larger ports requiring constant maintenance dredging, traditionalism and individualism are bound to operate against any quick change, even where it is proved to be justified on economic grounds.

On the other hand, at some other seaports where maintenance requirements are small, involving the use of plant for only a few months in the year, the wisdom of the policy of owning and operating dredging plants seems more open to question. On the face of things, it would seem an uneconomical practice, and there would appear to be greater possibilities of a change of policy in such quarters in favour of the contract system.

There is as yet no sign that such a change is imminent for even in the quarters referred to, tradition, or, as some might say, conservatism, would have to be unseated if a change is to be brought about to the contract system as prevailing in Holland.

Port of Lake Charles, Louisiana, U.S.A.

A Recent American Enterprise

(CONTRIBUTED)

Having confidence in the feasibility of a port for deep-sea traffic at Lake Charles, Louisiana, the citizens of Calcasieu Parish, by their own efforts and expenditures, have brought into existence the channel and Port of Lake Charles, which to-day represents an investment of over 6½ million dollars.

Quayside Operations at Port Terminal, Lake Charles Harbour.

The port is a state agency, and is located in a political subdivision known as the Lake Charles Harbour and Terminal District, situated entirely within the boundaries of the Parish of Calcasieu. The district was created by a special Act of the State Legislature, ratified by the Governor, July 7th, 1924. The district is governed by a Board of Commissioners, all of whom are appointed and commissioned by the Governor.

It is one of the few ports in the United States which has been constructed and financed entirely by local funds, and is also one of the few ports which is self-sustained.

The Port of Lake Charles was officially opened to traffic in November, 1926. Since that time the port has grown very rapidly, and regular steamship services have been established to Pacific and Atlantic Coast ports of the United States, and to the principal ports of Europe, South America and the West Indies, with irregular sailings to all world ports.

The Port of Lake Charles is served by three trunk line railroads, viz., the Kansas City Southern, the Missouri Pacific, and Southern Pacific Lines, and in addition, it is on the Intracoastal Canal. The port has very advantageous rail and water rates, and shippers find quite an advantage in despatching their goods through the Port of Lake Charles. The public terminal facilities consist of two wharves, each 1,600-ft. in length, giving a total of 3,200 lin. ft. of berthing space, with a covered area of 440,000 sq. ft. The wharves are equipped with double marginal tracks on the front apron, which permit of the handling of cargo direct from rail to ship. There are double depressed tracks to the rear of the wharves, and in addition, a number of storage tracks for the accommodation of freight awaiting arrival of steamer. The transit sheds are large and well ventilated, and the facilities as a whole are modern in every respect.

From the beginning the port has shown a steady increase, and in addition to the public terminals, seven private terminals have been constructed and are in operation. During the calendar year 1936, there was a total of 472 ocean-going ships, lifting and discharging a total of 2,866,255 tons of cargo, valued at $34,782,037.

Just to the rear of the public docks are the facilities of the Lake Charles Compress and Warehouse Company, which consist of a high density compress, cotton warehouses, classing room, office building and large receiving room. With these facilities, the compress company has a seasonable capacity of 300,000 bales.

The present ship channel has a depth of 30-ft., with a minimum bottom width of 125-ft. The channel follows the river a short distance south, where it intersects with the Intracoastal Canal, which has been widened and deepened and runs in a straight line for 21 miles, forming one of the longest and straightest artificial channels of deep water in the country. It joins the Sabine River below Orange, Texas, and enters the Gulf of Mexico through Sabine Pass. The distance from Lake Charles to the Gulf by this route is 75 miles.

For a number of years the interests at Lake Charles have been endeavouring to get a direct channel opened up from Lake Charles to the Gulf, through Calcasieu Pass, which would reduce the distance between Lake Charles and the Gulf of Mexico by about one-half of the distance via the present route. The U.S. Army Engineers have just recently recommended this channel, and the project became a part of the Rivers and Harbours Omnibus Bill, which has been passed by Congress and signed by the President. The channel will have a bottom width of 250-ft., and a minimum depth of 32-ft., and between the jetties a width of 400-ft. and a depth of 32-ft. The Act also provides for lights and other aids to navigation. With the completion of this channel, the number of steamship lines serving the port should be greatly increased, and with such new services opening up additional foreign markets for the port, the business should continue to increase each year for the next ensuing years.